DESIGN edition

Linear Programming

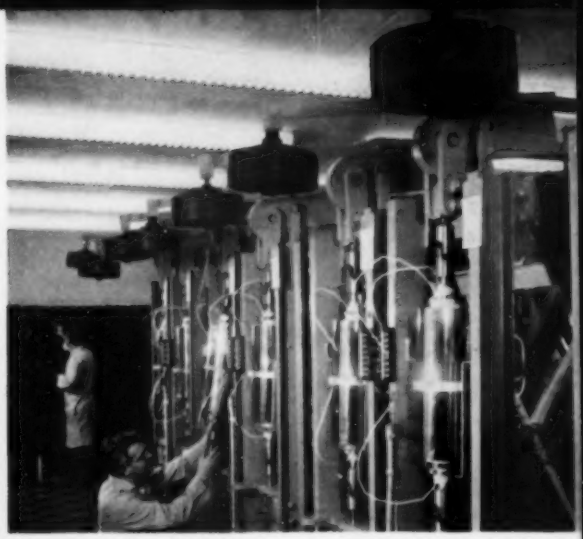
Protecting Motors

Gear-profile Errors

Product Engineering

McGRAW-HILL MAGAZINE OF DESIGN RESEARCH AND DEVELOPMENT

October 14, 1957 PRICE 50 CENTS



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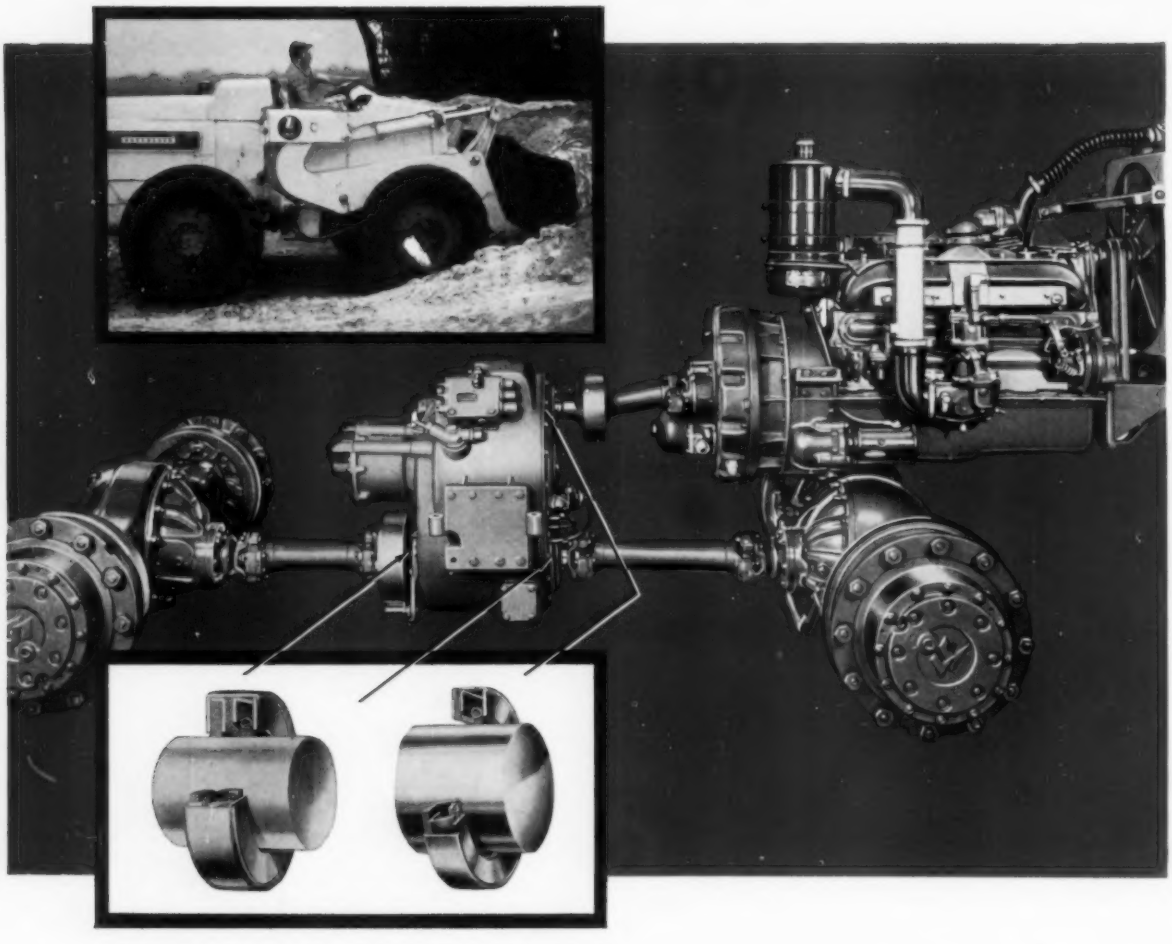

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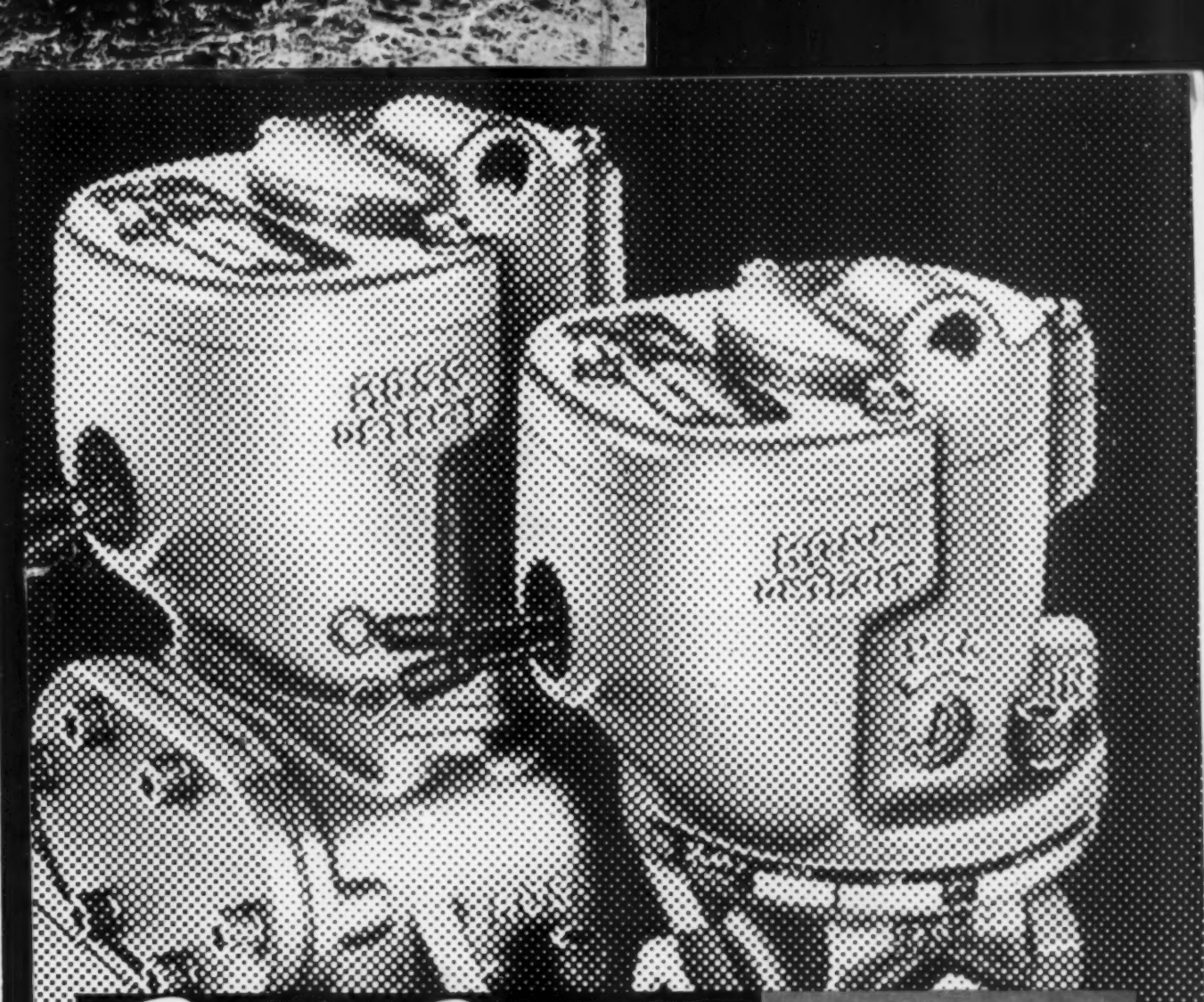
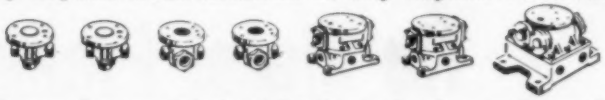


Ross-Skyline

Silvermodel JIC Spool Solenoid

Any Skyline Head Attaches to Any Skyline Valve Body



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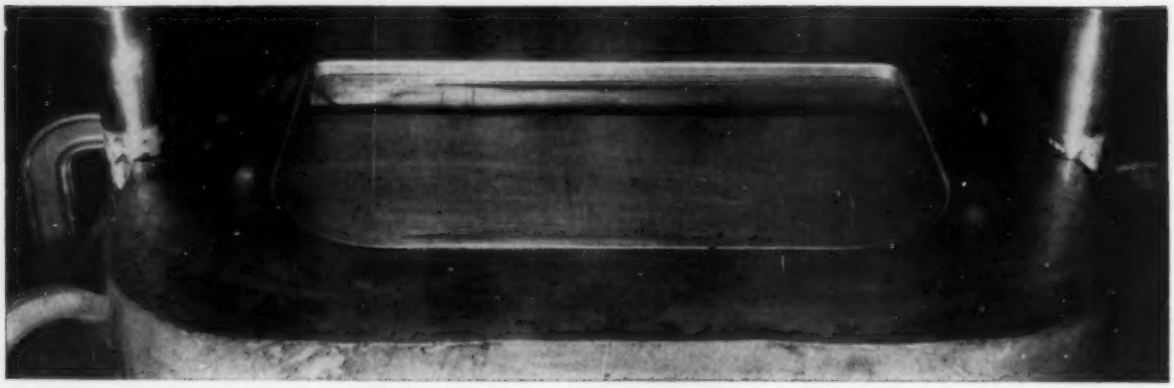

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No Maintenance

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67 Wall Street New York 5, N. Y.

ductile iron...the cast iron that can be twisted and bent.

Product Engineering

THE McGRAW-HILL MAGAZINE OF DESIGN, RESEARCH AND DEVELOPMENT

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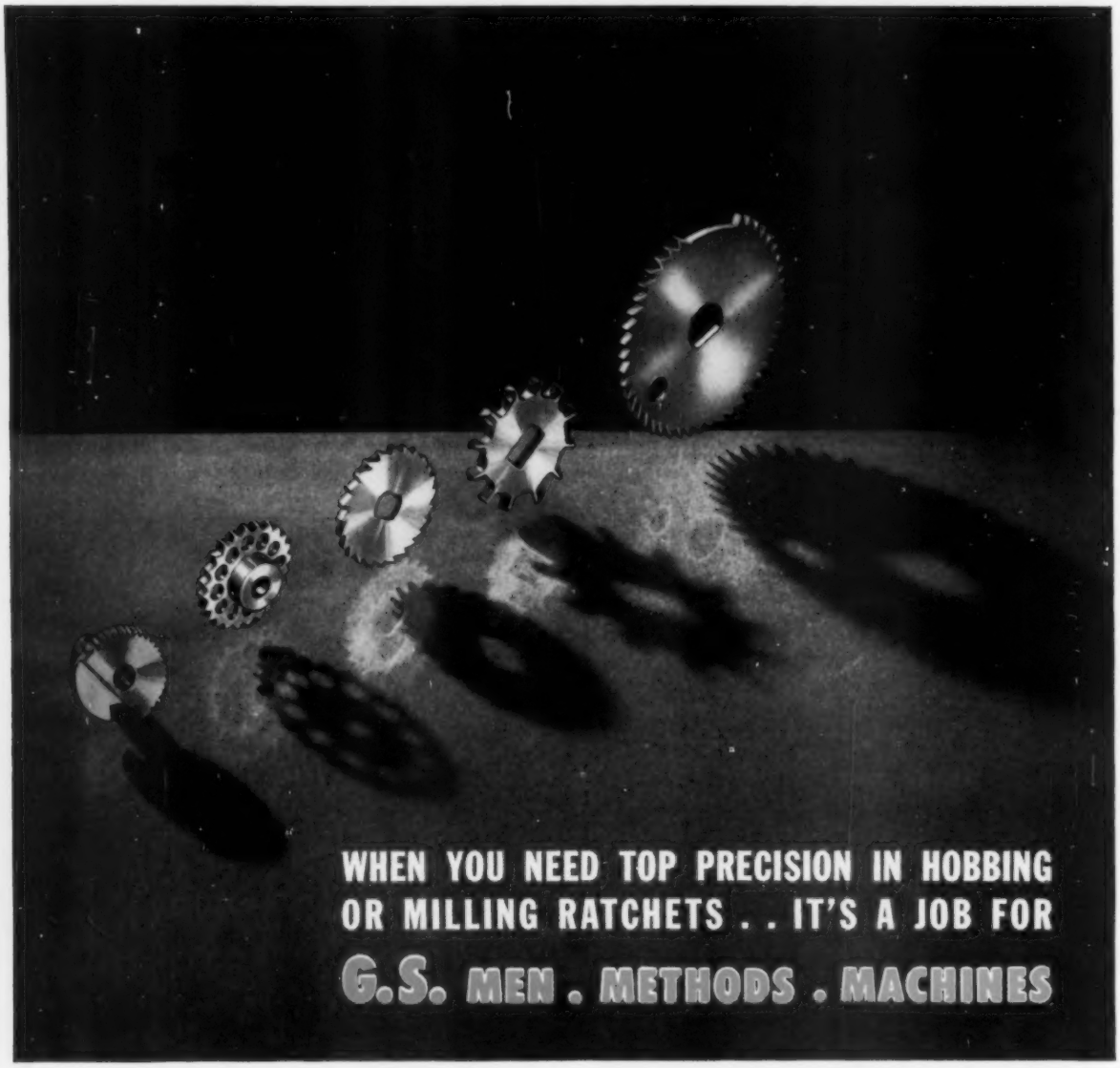

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Interesting to Note . . .

Corrosion By The Sea

"The little toy dog is covered with dust,
But sturdy and stanch he stands;
And the little toy soldier is red with rust,
And his musket moulds in his hands. . . "
—Eugene Field

Tanks and jeeps rotting in a torrid jungle were no nursery rhyme during the second world war. It was a totally unexpected enemy that attacked the allied forces in the South Pacific island-hopping operation.

A jeep or truck left in the open for 48 hours would rust so badly it couldn't be started. Thousands of replacement parts shipped in wooden boxes would arrive so corroded they were useless. Reliability of communications systems and radar gear was alarmingly low. Fungi attacked everything from tents to optical instruments, often so vigorously that glass surfaces were etched. It wasn't until the war's end, after research groups were established, that the corrosion problems were understood and in some cases solved. Today, industry fights these problems.

The Corrosion Research Council, a recently formed group eager for industrial support of corrosion research, reports that corrosion is reducing the profits of American industry by more than $5 billion annually. The International Nickel Co. has been studying the effects of corrosion for years, and our cover shows their large test station at Kure Beach, N. C. It was established in the Thirties by Frank La Que, vice-president of research at International Nickel and chairman of the Corrosion Research Council.

The cover insert shows researchers at another test center, U.S. Steel's Monroeville, Penn., plant, measuring the effect of temperature by means of creep-rupture tests as an aid in developing new alloys that will stand up under heat.

Too Many Pets

Not long ago, a New York woman was accused by her neighbors of keeping too many pets in her apartment. The neighbors didn't object to one or two, but 61 dogs and 15 cats seemed an overabundance of kindness. The sound of barking dogs and fighting cats, plus the sanitation hazard, finally forced the ASPCA to step in and find foster homes for the animals.

Actually, the problem was not particularly complicated. The ASPCA simply took 60 dogs and 14 cats, and found homes for

(Continued on page 7)

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TROUBLES

FROM DIRT OR **CORROSION**

(AND WITHOUT COSTLY FILTERS AND OILERS)

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Low Maintenance	Sealing qualities do not diminish with long, continued use.	Wear compensating "Shear-Seal" design.
Long Service Life	No production delays. Maintenance (rarely needed), without disturbing plumbing.	Lapped metal to metal sealing members.
Not Critical to Dirt	No scoring or binding. (As with spool or poppet designs.)	Flow is through "Shear-Seals." Sealing surfaces remain in constant intimate contact.
No Creeping Cylinders	Leakproof closure. (No internal port to port leakage.)	Maintained through lapping action of each operation.

Ask for bulletin A-5.

Foot operated models with or without spring return to reverse or to center are $24.50 list for the ¼" and $25.50 for the ⅜" valve less quantity discounts.

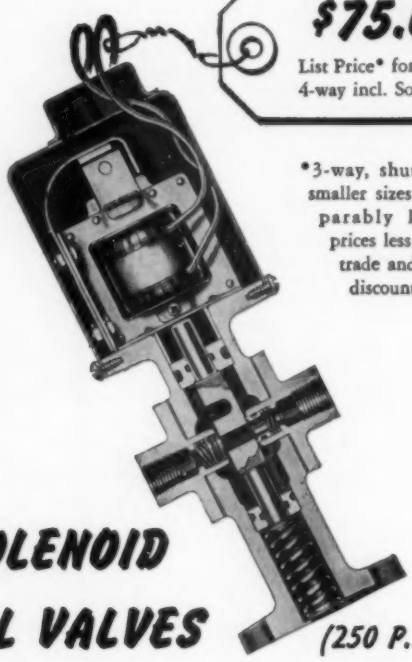
BARKSDALE VALVES

5125 Alcoa Avenue, Los Angeles 58, California

LEAKPROOF (SHEAR-SEAL)

$75.00
List Price* for a ½" 4-way incl. Solenoid

*3-way, shut-off and smaller sizes are comparably less. All prices less the usual trade and quantity discounts.



SOLENOID OIL VALVES (250 P.S.I.)

WHERE	WHY	HOW
Thread rolling machines	Holding position (leakproof)	Lapped sealing surfaces seal tight indefinitely as a result of wear compensation
Pressure testing in automotive production	Oil gets contaminated by scale in castings (not critical to dirt) reduced maintenance	Sealing surfaces in constant, intimate contact, dirt can't lock valving members—saves coil burn-out
Hydraulic work feed apparatus	(Leakproof) . . . as versus spool valves which cause overdemand on hydraulic system	Positive shut off of internal port to port leakage and of course, no external leakage
Machine tool chucking & clamping	Maintaining safe holding pressure (leakproof)	Saving auxiliary equipment such as pilot operated check valves
Automatic door openers	Quick action (high flow capacity)	No spools or poppets obstructing full, round flow passages
Solenoid controlled hydraulic system on machine you build	Better performance Lower manufacturing costs Reduce service problems	Shear-Seal valves have full flow, are leakproof, not sensitive to dirt Low priced, less auxiliary equipment and labor cost. Valves don't stick, saving coil burn-out; stay leakproof indefinitely, seals are wear compensating

BARKSDALE VALVES

5125 Alcoa Avenue, Los Angeles 58, California

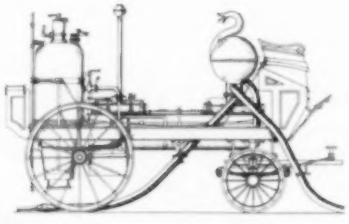
Ask for bulletin 5S-H

Interesting to Note . . . .

them in the city area. But suppose the woman wanted to spread her pets around the country? Shipping a small dog 3000 mi would require special care; dainty dogs need delicate handling. A larger dog would be costly to ship because of its weight. Somehow, she would have to appraise the dog's weight, the amount of care necessary and the distance to determine the cheapest way to distribute her pets. A solution would be practically impossible without linear programming (See article on page 92).

Actually a digital computer might be advisable—but what would it cost? Though the engineer is rarely faced with animal shipping problems, product distribution is a dog of another color. Here linear programming may be invaluable.

Nobody Wanted a Fire Engine



Perhaps the greatest single catastrophe to slow the march of science occurred in 47 BC when Caeser's legions set fire to the great library of Alexandria. Fire has always been a plague to man and industry. On three separate occasions it nearly leveled London in conflagrations largely the result of insufficient fire-fighting apparatus.

To meet the needs of London, young John Ericsson, later to conceive the ironclad *Monitor*, designed and built the first steam fire engine. In it, he introduced an artificial-draft boiler, supplying the air for combustion by a reciprocating blowing machine worked by the engine. On the frigid night of its first trial, it successfully pumped water for five hours without a hitch, while hand-engines quickly froze and became useless. After Barclay's brewery burnt to the ground, Ericsson's engine was borrowed and kept at work day and night for a month—pumping beer from one vat to another.

Unfortunately, London firemen and manufacturers of the old hand pump were against it—"You have to keep up steam . . . it's too powerful . . . too heavy . . . requires more water than London can provide." This barrage of protests caused Ericsson to withdraw in disgust. London worried along with its fire menace.

All civic leaders today must face the problem of fire and disaster control. A new disaster vehicle, pictured on page 80, will find service in our smaller communities. It not only fights fires, but doubles as police car, ambulance, and rescue unit.

Preserves for Napoleon

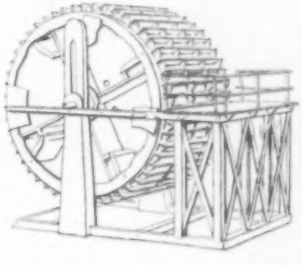
As the present-day logistician well knows, an army does travel on its stomach. Napoleon coined the expression, and in an effort to make it easier to feed his troops offered 12,000 francs to anyone who could find a better way of preserving food. In 1810, Nicolas Appert, a Paris candymaker, collected the award with his discovery that foods sealed in glass bottles and cooked in boiling water, would keep indefinitely.

Appert's process was adopted by five brothers named Ball in the 1870's. Using the patented screw-cap Mason jar, they began preserving fruit. The business grew, despite a fire that destroyed their early factory, until Ball Brothers Co. became a leader in the home-canning supply field.

Initially, glass jars were blown by skilled artisans who personally signed each piece. Annual capacity was somewhere around 3 million units. Today, the company puts out around 720 million pieces per year.

Uses of glass are no longer limited to bottles and window panes. You can, if you like, wear a glass suit in a glass boat and catch fish with a glass pole. Recently a new material, Pyroceram, was announced as a glass nose cone for missiles. On page 68 another new development in glass is discussed—a method that produces the fine grain desired for stronger castings.

Duchess, Keep Cool



How refreshing to stop in a store or office that's displaying the sign "Air Conditioned." It's easily forgotten that a few years ago the only escape from summer heat was a cool shower or a day at the beach. Back in the 15th century, the Duke of Milan was also troubled by hot summers. His wife, Beatrice d' Este, couldn't get any sleep—the heat was just too much for the Duchess. Leonardo da Vinci was called in and, for the first time, assembled a strictly mechanical air conditioner. Da Vinci built a 12-ft paddle wheel and set it in the river outside the castle. Inside the wheel he installed four weighted air scoops. As the wheel turned, the scoops picked up cool, washed air at the brim and pushed it into a hollow center shaft, through a conduit and into the Duchess' boudoir.

Back in 1920, practically all air-conditioning installations were based on industrial needs. Carrier Corp. was the first to introduce a centrifugal compressor. Among the innovations in Dr. Carrier's design was a compressor with operating speed of approximately 3500 rpm. At that time, reciprocating compressors were operating at 70 to 100 rpm.

Air can now be temperature-controlled for easy living. Air has also found application in industry—riveting, grinding, and powering controlled movements. If you have opportunities to use air as a power source the article on page 72 will be of interest.

—Benedict A. Leerburger Jr.

Contact speed and burning are
rectly related — excessive burning
of contacts will occur with either too
slow or too rapid contact break. The
former delays arc extinction, the
latter frequently causes flashover be-
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Developments

To Watch

ROCKETS AS MACHINE COMPONENTS?

. . . The idea is not as far-fetched as it might seem. A baby rocket, weighing little more than half a pound and delivering a 40-lb thrust, is soon to be available commercially. One promising application is in fast-acting, emergency shut-down devices for machines. It could also be used for shock and impact tests.

Because this is one of the first devices of its type, it won't be inexpensive—for a while, at least. Its price will be $150 to $200. But its developer, Atlantic Research Corp., Alexandria, Va., points out that if demand justifies quantity production, the price could come down. The rocket carries an Arcite charge (Atlantic's own composite solid propellant) and is about 5 in. long, 1½ in. dia.

STRONGER BONDS BETWEEN PLASTICS AND METALS . . .

. . . are promised by research at Bell Telephone Laboratories. It has a new technique and a new adhesive for bonding polyethylene to brass and natural rubber that may provide a breakthrough for other plastics as well. As Bell Labs describes the new bonding process, it calls for moderate pressure (100 lb or less) plus heat—250 F to 300 F. The adhesive is a partially-hydrogenated polybutadiene, Phillips Petroleum's Hydropol. It can be applied by dip, brush, or spray; or fabricated into thin sheets. Expected applications: bonding of insulation to conductors, bonding of linings to tanks, polyethylene-coating of mechanical parts.

WHERE CAN SLACK-QUENCHED STEELS BE USED?

. . . The National Bureau of Standards is out to find an answer. NBS believes that costly deep-hardening alloy steels are frequently specified where carbon steels might be used—if only more were known about the properties of slow-cooled low alloys. Now, a new compact test has been devised and a study is under way.

The test uses Charpy (V-notch) specimens that have been immersion end-quenched. This treatment forms a series of planes having different but predictable microstructures and hardnesses, depending on their distance from the quenched end. The impact resistance is then measured at various points along the test bars, and compared with a standard Jominy bar end-quenched according to ASTM specifications.

IN MACHINE TOOLS AND TRACTORS . . .

. . . reinforced plastic paneling is getting new and important jobs. Gisholt Machine Co., which introduced reinforced plastic paneling on its bottle-capping machines about two years ago, is now extending it to several machine tools (see photo). Now, a tractor company is experimenting with glass fiber-reinforced plastics for fenders and hoods; and appliance makers, too, are extending their use of the material.

—A.R.G.

Easy to handle,

Fiberglas-reinforced plastic paneling for Gisholt Superfinisher is also easy to install. Resin in this laminate is Plaskon polyester. Advantages, says Plaskon, are: light weight, corrosion resistance, moderate cost. Panels also lend themselves to attractive styling, provide insulation against noise. (For other news of machine tool design, see Sept. 23, p. 25.)

MANY FACTORS CONTRIBUTE TO LOW INSTALLED COST OF SOUTHCO DRIVE RIVETS . . .

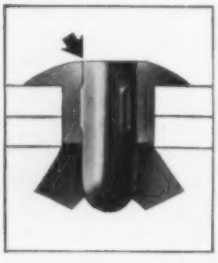
ECONOMICS OF FASTENING COVERS FULL CYCLE FROM INVENTORY REQUIREMENTS TO FINISHED PRODUCT

Designers who specify fasteners realize the many considerations that enter into cost determination. While ease of installation is often the most important feature, other factors affect costs. It may be difficult to put a dollar value on availability, for example, but serious financial losses do occur when production is held up or shipping dates are missed because of a slow fastener delivery. Being able to ship from stock, as Southco does, helps avoid production delays.

ELIMINATION OF SPECIAL TOOLS

Down time due to special tool failure and maintenance of special fastening tools are two fastening costs which are eliminated by Southco Drive Rivets. The only tool required is a hammer . . . any kind of a hammer . . . claw or ball, and size is not important. The number of men on a Southco riveting job is never limited by the number of special tools on hand and in working order.

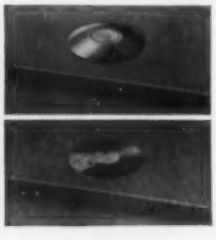
QUICKLY SET



To install, Southco Rivets are placed in drilled hole. The pin is then driven with a hammer. Installation is complete. No bucking is required.

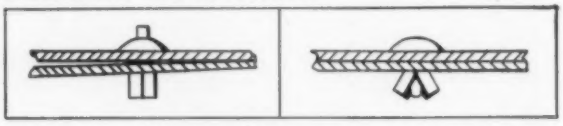
Expanded prongs force parts together. Pin is locked securely into rivet by displaced metal filling unique grooves. Compression forces are utilized for greater strength.

NO FINISHING OFF, NO WASTE



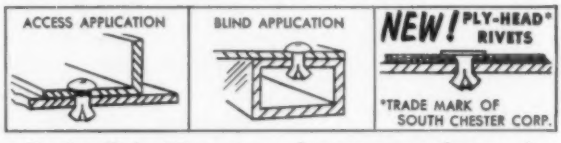
Impact of hammer seals pin neatly in rivet. No part of the rivet is cut off and discarded. No time-consuming filing, grinding or polishing is necessary. No scrap to clean up.

AUTOMATIC "PULL-UP" ACTION ASSURES TIGHT JOINT



Even when adjacent surfaces are separated, parts are forced together by Southco Rivet action, then held tightly in compression.

WIDE RANGE OF APPLICATION



Southco Drive Rivets are used to secure metal to metal or metal to wood. They are equally adaptable to blind or open applications. In each, they are quickly set and grip tightly. New PLY-HEAD* rivet permits higher loading of "soft" materials such as plywood, plastics and composition.

AVAILABLE IN ALUMINUM OR STEEL

Southco Rivets are supplied in aluminum or cadmium plated steel. The aluminum rivets have either cadmium plated or stainless steel grooved pins. The steel rivets have cadmium plated steel grooved pins.

Standard head designs are Universal or Countersunk. Full Brazier heads are available in popular sizes. New PLY-HEAD rivet rounds out line.

ALUMINUM

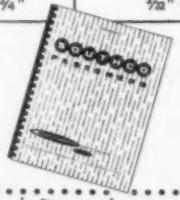
DIAMETERS	LENGTHS	NOMINAL GRIPS
1/8"	1/8" to 1/2"	1/32" to 13/32"
5/32"	7/32" to 3/4"	1/16" to 5/8"
3/16"	1/8" to 3/4"	1/32" to 5/8"
1/4"	7/32" to 3/4"	1/16" to 5/8"

STEEL

DIAMETERS	LENGTHS	NOMINAL GRIPS
1/8"	1/8" to 1/2"	1/32" to 13/32"
3/16"	1/4" to 3/4"	3/32" to 5/8"
1/4"	1/4" to 3/4"	3/32" to 5/8"

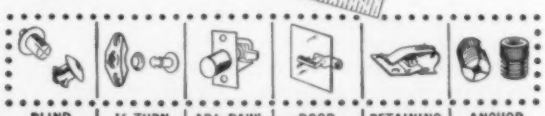
FREE FASTENER HANDBOOK . . . Send for your free copy of Fastener Handbook No. 7, just released. Gives complete engineering data on these and many other specialty fasteners. 52 pages, in two colors.

Write on your letterhead to Southco Division, South Chester Corporation, 236 Industrial Highway, Lester, Pa.

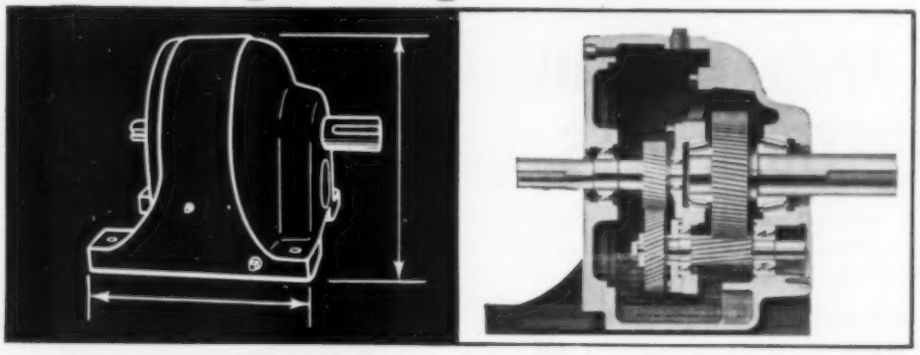


SOUTHCO FASTENERS

©1957



NEW compactness outside...
NEW simplicity inside...



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ONE LOW-SPEED GEAR SET per drive size and maximum accessibility of all operating parts simplify servicing and ratio changes.

...and built for smoother speed reduction *all the way around*

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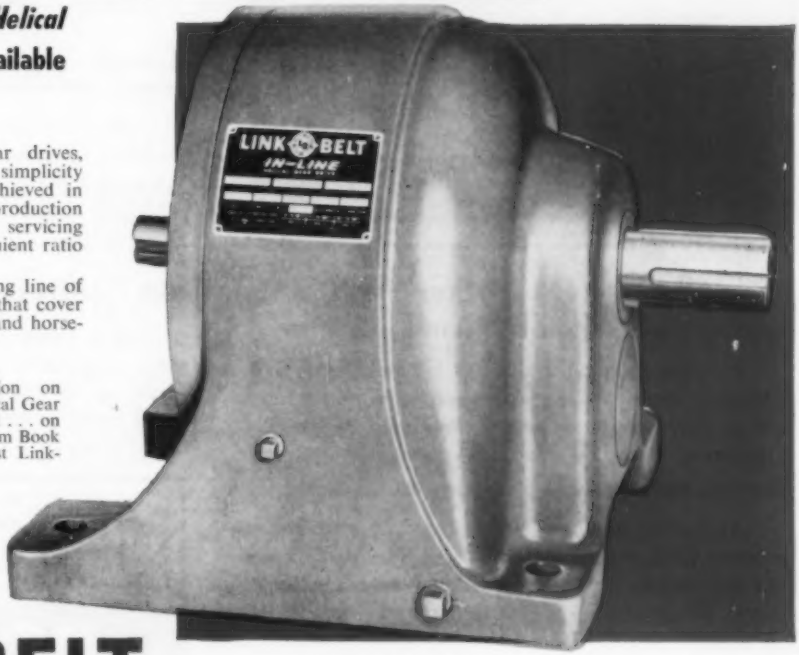
Get full information on Link-Belt In-Line Helical Gear Drives from Book 2651 . . . on parallel shaft drives from Book 2619. Ask your nearest Link-Belt office.



Available with double or triple gear reductions . . . ratios 6.2:1 to 292:1 . . . capacities to 118 hp. Conform dimensionally with new NEMA motor sizes.

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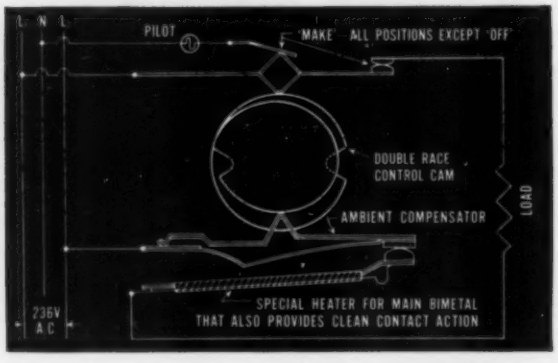

Model 510—
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The basic unit in the PROCTOR family of controls. Its purpose is to provide infinite, stepless control of wattage input at any preselected setting from 6 to 100% of rating.

Other PROCTOR Infinite Controls are:

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Accurately maintains any preselected temperature between 120° and 450°F. A sensing device in contact with the heating surface acts with the remote selector-control to proportion wattage input for any heating load.

These PROCTOR controls are small, easily installed and have a minimum of operating parts and electrical connections. There are no motor driven cams or sliding contacts. Life tests up to ¼ million cycles show negligible contact wear. There are models for loads up to 3000 watts at 236 volts A.C., and to 1500 watts at 118 volts A.C. Flasher units operate at 6400 watts at 236 volts A.C.

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4 oz. per sq. ft. (.0056″)
5 oz. per sq. ft. (.0070″)
6 oz. per sq. ft. (.0084″)
7 oz. per sq. ft. (.0098″)

WIDTHS. Slit to ordered widths in ½″ increments from 6″ to 62″ trimmed, or 64″ untrimmed.

LENGTH. In continuous length rolls, varying by gage. Only limiting factor is weight of full-width roll.

COMMERCIAL QUALITY. Available in the full range of gages.

PRINTED-CIRCUIT QUALITY. Quality carefully controlled to conform with N.E.M.A. Specification for copper foil. Clean, bright surface on one side relatively free from pits, scratches, nodules, and surface inclusions. The reverse side has a matte finish for high bond strength between the base material and the copper. Furnished in gages from 1 oz. per sq. ft. (.0014″) to 7 oz. per sq. ft. (.0098″) and to exceptionally close gage tolerances of ± .0003″ for 1 oz. and 2 oz., and ± .0006″ for 3, 4, 5, 6 and 7 oz. weights.

FURNACE-BRAZING QUALITY. Clean and free from surface residues. Furnished in thicknesses from 1 oz. to 7 oz. per square foot.

ELECTROSTATIC SHIELDING. To prevent leakage, in or out, of stray currents which affect the proper functioning of electrical equipment—transformers, radio and TV receiving sets, electrodiathermy equipment – broadcasting buildings, hospital operating rooms, X-ray rooms.

DAMP-PROOFING AND VAPOR SEAL. "Electro-Sheet" is available bonded to high-grade building paper, cloth, or asphaltic compounds —strong, flexible, easy to handle—an economical solution to many varied problems of water-, moisture-, vapor-, and wind-proofing.

GASKETS. "Electro-Sheet" bonded to paper, fabric, or compounds.

CAPPING. For such things as utility poles and fencing to prevent moisture from entering open end pores of wood, causing rot.

CABLE WRAPPING. Bonded to paper or fabric, and corrugated to conform to spiral winding without rupture.

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PRINTED CIRCUITS. Rigidly controlled quality "Electro-Sheet" for the exacting use of fabricating electric circuit wiring by the printing-etching method and by die stamping.

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"Electro-Sheet" Copper Foil was developed by Anaconda to provide the positive and durable protection of copper at low cost. It is nonrusting, vermin-proof, nonflammable and impervious to penetration by water, air, or moisture. For detailed information or help in application to your products write: The Ansonia Division, The American Brass Company, Ansonia, Conn. 8732

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Plastiatrics

DOW'S CLINICAL APPROACH TO HEALTHY PLASTICS APPLICATION

STRESS CONSIDERATIONS IMPORTANT ENGINEERING ASPECTS OF POLYSTYRENE

RIGIDITY IS NOT ALWAYS BEST INDICATION OF PLASTIC PRODUCT STRENGTH

Great care must be taken when designing a molded plastic part to avoid stress concentrations. The part must be designed so as to distribute energy absorption over as much of the area of the part as possible. Designers often place a reinforcing rib to add stiffness and the result is an area of concentrated stress which causes the part to fail after a short period under load.

Dow Plastics Technical Service Engineers have made a detailed study of the many important engineering aspects of molded polystyrene. Greater over-all strength can often be attained simply by molding a thicker part, rather than by adding ribs which may concentrate stresses.

Thermally induced stresses caused by differential cooling of the part can be reduced by proper design. As a part with an extreme difference in sectional thickness cools after fabrication, the thinner section cools more rapidly. Subsequent cooling and shrinkage of the thick section will cause a sufficient amount of bending in the already hardened thin section to introduce tensile stresses which cause crazing under small loads.

Orientation stresses caused by forced molecular alignment can be controlled to some extent by the design engineer. By considering the fabrication of the part he can usually place the requirements of maximum strength across the direction of orientation.

Dow Plastics Technical Service Engineers have also investigated various factors affecting the physical properties of polystyrene such as aging, temperature and environmental effects, chemical resistance, dimensional stability and many others. This is but one of a series of continuing Plastiatrics studies covering every phase of plastics formulation, design, molding and finishing. For your copy of the paper entitled, "Engineering Aspects of Polystyrene", write THE DOW CHEMICAL COMPANY, Midland, Mich. Plastics Sales Dept., 1546G.

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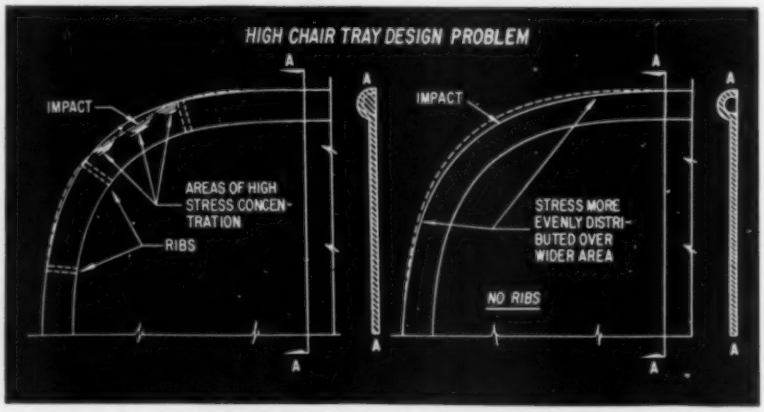
- STYRON 777 (Medium Impact)
- STYRON 440 (Heat Resistant)
- STYRON 480 (Extra-High Impact)

HEAT RESISTANT
- STYRON 683
- STYRON 700



High chair tray shown above, left, is an example of what happened when the design was too rigid. Ribs were used extensively as shown. When the tray was dropped on its edge, the force of impact was concentrated between two ribs and the rim broke. When tray was molded without ribs, above, right, the force of impact was spread, the deflection less, and the rim did not break.

YOU CAN DEPEND ON DOW

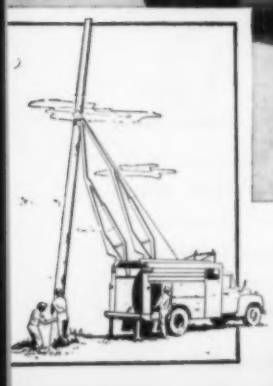
SHELBY SEAMLESS TUBING helps "Pole-Master"* handle poles like matchsticks

THE POWERFUL, two-legged boom of this "Pole-Master" Hydraulic Derrick is made of cold drawn tubes of USS Shelby Seamless Mechanical Tubing. Capable of handling poles up to 75 feet in length with relative ease, the boom is activated by two hydraulic cylinders, also of Shelby Seamless, which are powered by a heavy-duty hydraulic pump. The derrick has an operating arc of more than 180 degrees, and is designed to "set" poles or "pull" them from the ground. The "Pole-Master" can be used under the most severe work conditions in any weather or climate.

Here is an application in which Shelby Seamless Tubing really excels, for it brings into play all the desirable qualities that Shelby Seamless possesses—high strength, uniformity, shock absorbency, dimensional accuracy, lightness and workability.

Produced to exacting standards by the world's largest manufacturer of tubular steel products, Shelby Seamless is available in a wide range of diameters, wall thicknesses, various shapes and steel analyses. You are invited to call on our engineers for assistance. They will be happy to submit recommendations based on a study of your particular requirements.

**Manufacturer's name on request.*



NATIONAL TUBE DIVISION, UNITED STATES STEEL CORPORATION, PITTSBURGH, PA.
(Tubing Specialties)

COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS • UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS

SHELBY SEAMLESS MECHANICAL TUBING

A PRODUCT OF NATIONAL TUBE

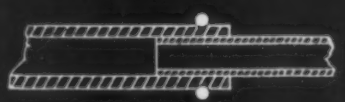
UNITED STATES STEEL

FIRM GRIP NO SLIP

make hose connections faster with

EATON-RELIANCE

HOZ-FAS-NERS®



Production and maintenance men acclaim Eaton-Reliance Hoz-Fas-Ners for speeding up operations, cutting costs. Usable on rubber, plastic or fabric hose, they're always on the job — exerting continuous, uniform pressure at all points.

On assembly line operations, savings in time and motion are substantial with Hoz-Fas-Ners, compared with other type hose clamps. On service . . . removal and replacement of hose is greatly simplified. Hoz-Fas-Ners never need adjustment or retightening — they are vibration-proof and don't work loose.

Hoz-Fas-Ners can be installed quicker than other type clamps . . . no screws to turn, no nuts to put on, no preassembling. Hoz-Fas-Ners are fabricated from the highest quality alloy spring steel, and resist rust — your assurance of long life. Because of the round contours of the sections, the clamps have no sharp edges to cut into hose. They are re-usable — for additional savings.

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...*first thing instead of last*

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why shell castings from CENTRAL FOUNDRY DIVISION offer new design possibilities and reduced costs per part

In the shell-casting process phenolic resin is combined with sand for the mold material. This basic difference brings about a great many advantages . . .

Shell-cast castings give excellent duplication of detail since the curing of the shell on the pattern produces a hard, smooth mold which is as accurate as the pattern itself. Thus, shell molds permit deep pockets and recesses to be drawn, making possible complex designs impractical by any other method.

Central Foundry Division has been casting by the shell process since 1951. During that time, techniques have been brought to a high degree of perfection and control.

The absence of surface-sand on shell castings increases machine-tool life tremendously. At the same time, shell cast parts, being cleaner to start with, reduce or eliminate the need for additional cleaning by the customer.

The reduced machining and waste, elimination of costly cores, better surface detail, increased tool life and savings in machine scrap, combine to open countless new opportunities for you in both design and cost savings.

Perhaps shell castings can help you make your product still better and at a savings in cost. Shell castings are available in grey iron, alloy grey iron, malleable iron or ArmaSteel®. Write us today for your copies of the free, factual books, ARMASTEEL and SHELL CASTINGS. Or, tell us about your casting problems. Our research and engineering staff is ready to employ spectroanalysis, stress analysis, sonic testing, and other improved foundry methods in helping you seek a solution.

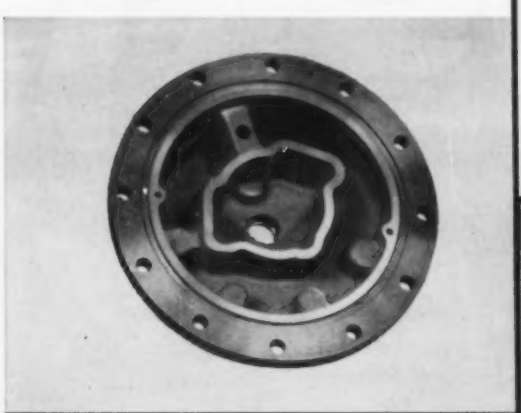
CENTRAL FOUNDRY DIVISION

GENERAL MOTORS CORPORATION • SAGINAW, MICHIGAN • DEPT. 10

Typical shell mold showing cope and drag

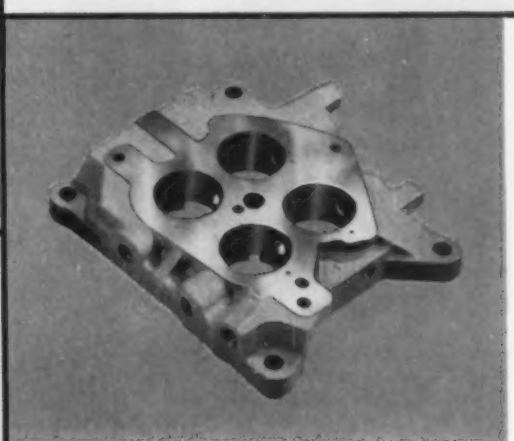
Shell molding permitted the casting of intricate grooves and recesses in this governor body which would be too costly by any other method

Machining of the O.D. was eliminated by shell casting this refrigeration compressor head



Better dimensional control by the shell process simplifies the balancing of crankshafts

Uniformity of shell castings makes automotive rocker arms more adaptable to automatic machining



Closer tolerances of shell castings often eliminate machining on clearance and non-functional surfaces

compact . . . power-packed

New General Electric

REDUCE YOUR

COMPLETE LINE AVAILABLE

INSTALLATION EASE is one cost-saving feature of new Tri-Clad '55' motors 7½-125-hp. Up to 32% lighter and 50% smaller, these motors offer greater handling ease. Easy-access conduit box and perma-numbered leads speed motor hook-up to help reduce your product cost.

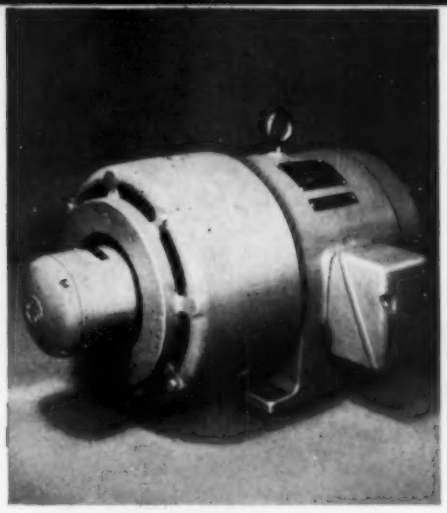
TRI 55 CLAD motors can . . .

REG. U.S. PAT. OFF.

PRODUCT COST

THROUGH 125-HORSEPOWER

UP TO 32% LIGHTER and 50% smaller, new Tri-Clad '55' motors make it possible to reduce the size and weight of your products, or, with minor design modifications get greater capacity out of present machines.



"SPECIAL" MOTORS are built in G.E.'s new motor factory almost as fast as standards. Orders for "specials," such as this Tri-Clad '55' brake motor with plugging switch, are normally filled and shipped within a few days.

IMMEDIATE SHIPMENT of all popular Tri-Clad '55' motor ratings through 125-hp is provided by G.E.'s modern production facilities and a nation-wide network of warehouses. Fast shipment cuts your inventory costs.

immediate shipment . . . all ratings

Today's highly competitive market demands that equipment manufacturers take every possible step to reduce costs while maintaining or increasing product quality.

To help you accomplish this objective, General Electric has extended the proven Tri-Clad '55' motor line (formerly available only through 30-hp) up through 125-hp.

DESIGNED TO NEW NEMA RATINGS, the *complete* line of Tri-Clad '55' motors packs *more* power into *smaller* enclosures to improve your product design, reduce shipping costs and benefit your overall operation.

In addition, G.E.'s modern, automated manufacturing plant and nation-wide warehousing facilities make it possible to *reduce your motor inventories.* Now, *any* frame size of *any* popular Tri-Clad '55' motor rating through 125-hp is available for immediate shipment from nearby warehouse or factory stocks.

FOR COMPLETE DETAILS on the new, complete Tri-Clad '55' motor line contact your nearest G-E Apparatus Sales Office or Authorized Distributor.

Section A891-8
General Electric Company
Schenectady 5, New York

Please send me the following publications:

☐ **FREE BULLETIN (GEA-6602) describes the many advanced features of new Tri-Clad '55' motors through 125-hp.**

☐ **FREE SLIDE RULE (GEN-148) to determine weight and space-saving benefits of new Tri-Clad '55' motors.**

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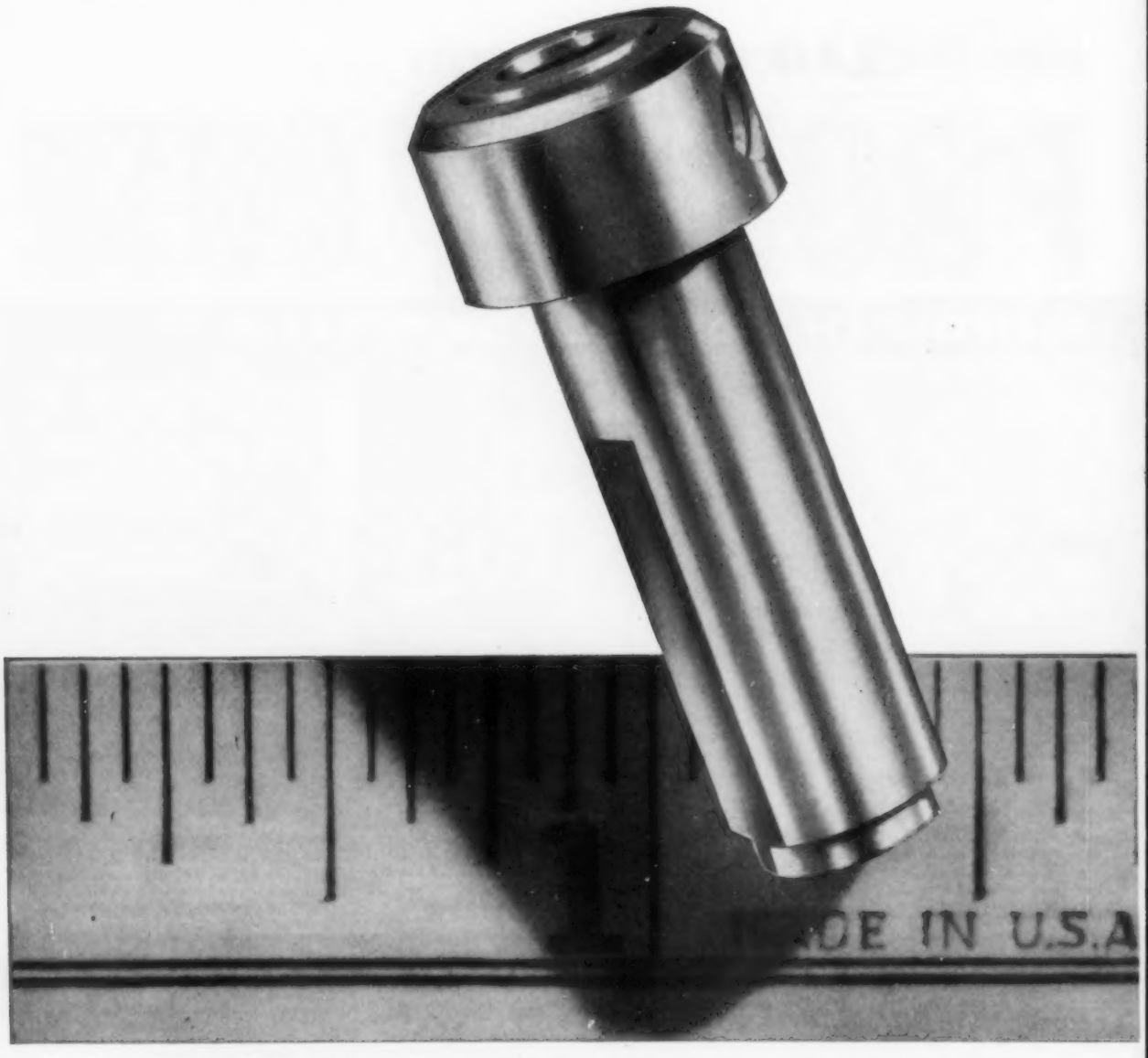

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on one part alone when they

SWITCHED TO ALCOA ALUMINUM* SCREW MACHINE STOCK

Mr. Len Mayeron, Chief of Components and Materials Section for Minneapolis-Honeywell, says, "This hub used to be made of cold-finished, free-cutting steel. It was switched to 2011-T3 Alcoa Aluminum Screw Machine Stock and now saves $2,350 annually. Even though steel costs less than aluminum, in this particular situation, savings in machining and scrap salvage more than offset the initial material cost."

If you machine parts from steel or brass, now is the time to take a hard look at these economic facts about aluminum:

1. Aluminum costs less than brass, and machines just as fast.
2. Aluminum machines faster than steel and won't rust.
3. Aluminum scrap allowance is high.

Now is the time to switch to Alcoa® Aluminum. To help you make that switch, call on your nearest Alcoa sales office. For immediate delivery of Screw Machine Stock, contact your nearest distributor. ALUMINUM COMPANY OF AMERICA, 865-K Alcoa Building, Pittsburgh 19, Pa.

HERE IS ACTUAL COST COMPARISON OF $2,350 SAVINGS ON THIS PART

Steel Cost per 1,000 parts:

78.5 lbs @ 11¢ per lb	$ 8.63
Less 64% scrap @ 1.1¢ per lb	.55
Net cost	$ 8.08 per 1,000

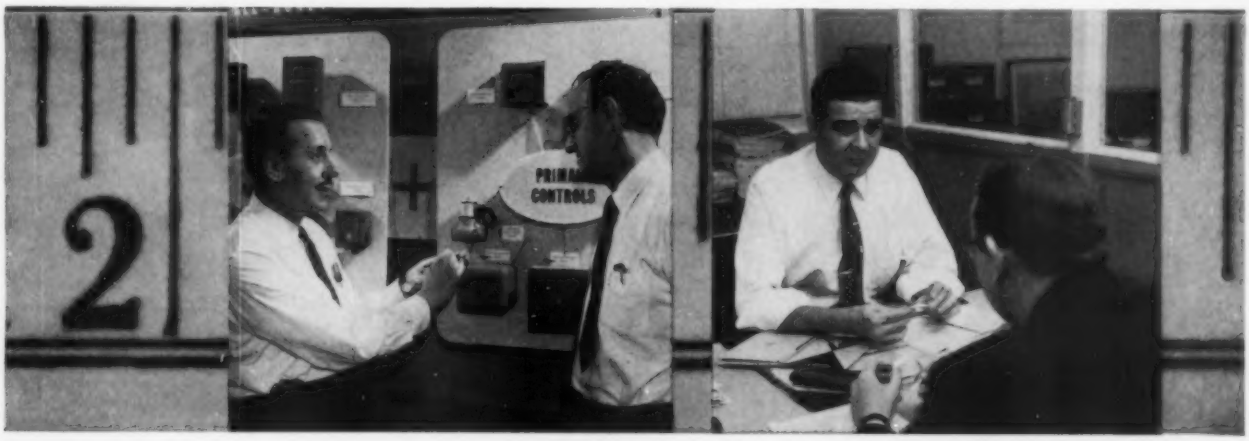
Aluminum Cost per 1,000 parts:

27 lbs @ 65¢ per lb	$17.55
Less 64% scrap @ 14¢ per lb	2.42
Net cost	$15.13 per 1,000

Steel machine time 7.86 hours per 1,000 parts.
Aluminum machine time 2.60 hours per 1,000 parts.

Labor savings 5.26 hours @ 2.265¢	$11.91
Less difference in material	7.05
Net savings per 1,000 parts	$ 4.86

Annual savings on this single-part total $2,350



IN ENGINEERING, Len Mayeron (Right), Chief of Components and Materials Section, discusses cost reduction with John Kriechbaum, Chief of Design and Development Department. Mr. Mayeron says, "We like Alcoa's technical literature and the way they pitch in and help us with production problems."

IN PURCHASING, Bill Smisek, Assistant Purchasing Agent, says, "Alcoa always meets metallurgical specifications. I seldom have had to reject their material. In emergencies, Alcoa seems to be able to find us extra quantities and give us faster than normal deliveries."

✻ LEARN WHY OTHER COMPANIES HAVE SWITCHED TO ALCOA ALUMINUM

Your Guide to the Best in Aluminum Value

WE CHOSE
ALCOA
ALUMINUM
SCREW MACHINE STOCK
ALUMINUM COMPANY OF AMERICA

NEW! "ALCOA THEATRE"—Exciting Adventure
Alternate Monday Evenings

Direct quotes from leaders in industry on why they buy from Alcoa.

Fill out coupon for your copy.

Name_____

Title_____

Company_____

Address_____

City_____ State_____

For whatever you make . . .

N-A-X® FINEGRAIN STEEL DELIVERS STRENGTH WITH TOUGHNESS

No more dramatic test of a steel's combined strength and toughness could be devised than the kind of job performance which Caterpillar Tractor Co. builds into its products.

As Caterpillar equipment literally moves the earth, bulldozer blade surfaces and scraper bowl bottoms must stand up to gruelling punishment. In these critical components, Caterpillar standards for steel are of the highest. N-A-X FINEGRAIN steel meets those standards with the right combination of strength with toughness.

And to this manufacturing operation, like so many others, N-A-X FINEGRAIN brings other important benefits as well. For example, the excellent weldability of N-A-X FINEGRAIN steel makes it exceptionally adaptable to Caterpillar's exacting requirements.

Review these salient advantages for your job: N-A-X FINEGRAIN steel, compared with carbon structural grades, is approximately 50% stronger • has high fatigue life with great toughness • is cold formed readily into difficult stampings • is stable against aging • has greater resistance to abrasion • is readily welded by any process • offers greater paint adhesion • polishes to a high luster at minimum cost. And the physical properties of N-A-X FINEGRAIN are inherent in the "as rolled" condition. N-A-X FINEGRAIN'S resistance to normal atmospheric corrosion is twice that of carbon structural steel.

NOTE: Where greater resistance to extreme atmospheric corrosion is an important factor, our N-A-X HIGH-TENSILE is recommended.

For whatever you make, from tractors to pressure cylinders, with N-A-X HIGH-STRENGTH steels you can design longer life, and/or less weight and economy into your products.

This bowl bottom assembly of the Caterpillar No. 470 Scraper requires numerous individual welding operations in its manufacture. Not only the parent metal, but the welds themselves, must have strength with toughness. Again, N-A-X FINEGRAIN *steel proves its excellent weldability.*

Here Caterpillar Earthmoving Equipment pushes America's great highway program forward. A Cat® DW 21 and matching No. 470 Scraper lead the way. The Cat DW 21 is assisted by a Caterpillar-built crawler Tractor.

N-A-X
HIGH-STRENGTH STEELS

N-A-X Alloy Division, Dept. C-9
GREAT LAKES STEEL CORPORATION
Detroit 29, Michigan • Division of
NATIONAL STEEL CORPORATION

N-A-X Alloy Div., Dept. C-9
Great Lakes Steel Corp., Detroit 29, Michigan

☐ Please send me technical data on N-A-X FINEGRAIN steel.
☐ Please have your representative contact me.

Name_____ Title_____

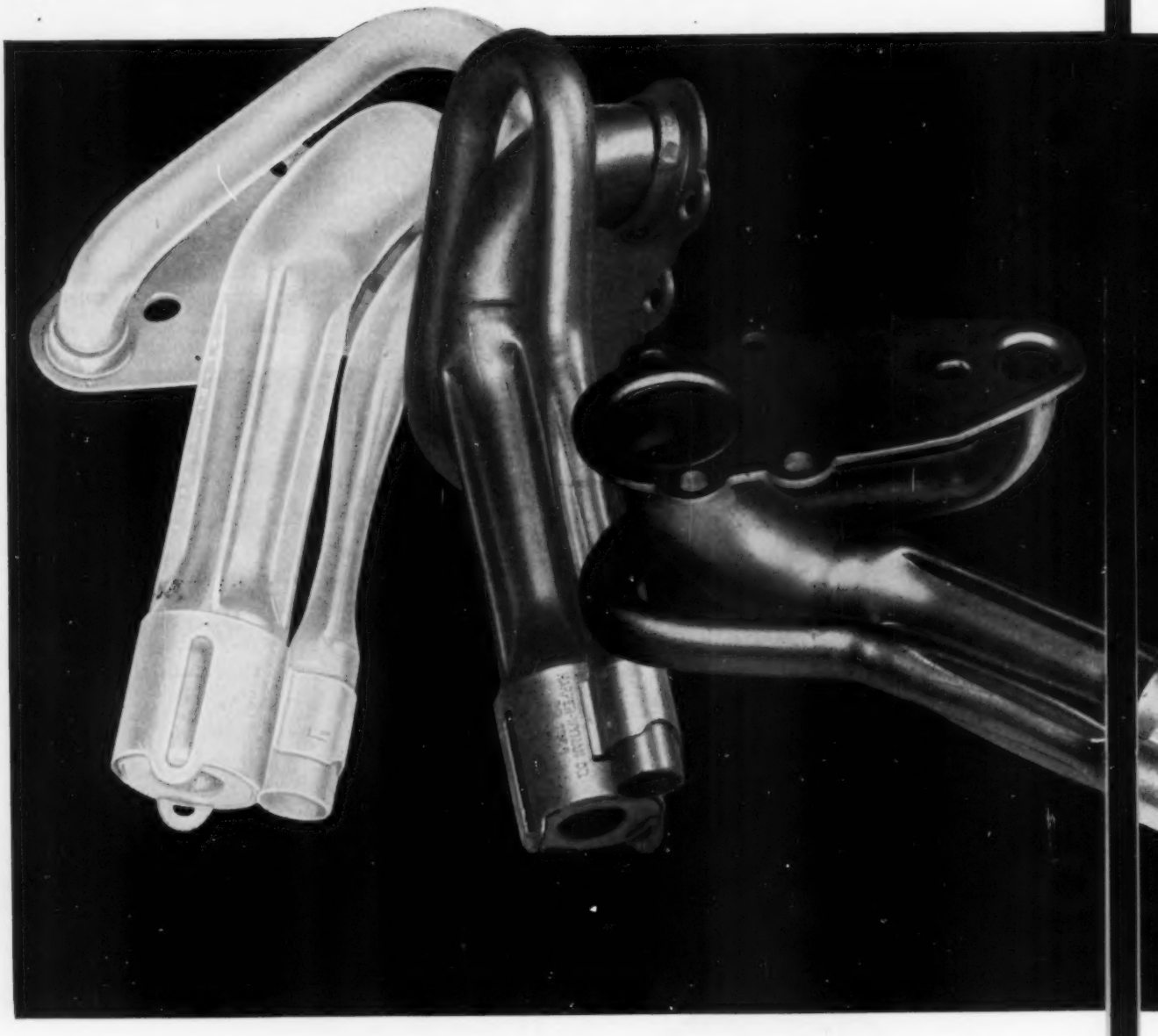
Company_____

Street_____

City_____ Zone____ State_____

Range-burner manufacturer does

REPUBLIC ELECTRUNITE



REPUBLIC

REPUBLIC STEEL

World's Widest Range of Standard Steels

everything but tie knots in this

STEEL TUBING

First, there's a hairpin bend to a 1¼-diameter radius! Then a 4-way crimp to form a finned venturi! Next some punching and notching! Followed by welding!

This is how Harper-Wyman Company turns Republic ELECTRUNITE® Carbon Steel Tubing into the lightweight, easy-to-clean venturi burner tubes used on scores of famous-name gas ranges.

All these severe bending and crimping operations depend on close tolerances on the O.D. and the I.D. of the Republic Steel Tubing to avoid die and mandrel troubles. Uniform, predictable ductility is a must to avoid stretch and collapse as the tubing is severely bent and formed.

Republic ELECTRUNITE Steel Tubing is uniform in wall thickness, fully concentric, and can be furnished with smooth surface finish inside and out. It is supplied in a full range of sizes, wall thicknesses, grades, and ductilities to meet any of your fabricating requirements. Dollar for dollar, your best tubing buy is Republic ELECTRUNITE, the *original* electric-resistance-welded tube.

Let our engineers help you design Republic ELECTRUNITE Steel Tubing into your products to speed production, cut costs, eliminate excess weight and improve product performance. Fill in coupon and mail today.

VOLLRATH COMPANY MAKES STAINLESS STEEL WASHER TUB IN ONE DEEP DRAW. For the Speed Queen automatic washer, Vollrath craftsmen start with a circular blank of Republic ENDURO® Stainless Steel. Then, in a single operation, they deep-draw the blank into a tub in which diameter of the blank is reduced 50%. Proof of ENDURO's ductility and workability! Installed in the Speed Queen washer, the stainless tub adds sales appeal, promises lifetime service. Where can you use ENDURO to improve product or process? Republic metallurgical help is yours for the asking.

TWO-YEAR-OLD DRIVER TESTS NYLOK NUTS. They are used at several critical points of the Taylor Tot manufactured by The Frank F. Taylor Co., assuring positive locking even under severe shock, vibration and tension. Republic Nylok Nuts lock whether seated or not, protecting painted surfaces and soft metals. Positive locking assured wherever you stop wrenching. Even a two-year-old can't shake 'em loose. Want test samples? Write Republic, indicating size needed.

GET ZINC COATING PROTECTION WITHOUT COSTLY DIPPING AFTER FABRICATION. You can, with Republic Continuous Galvanized Steel. That tight, corrosion-resistant zinc coating will not crack, flake or peel under any forming process permitted by the base metal. Result is long-lasting protection without costly dipping. And, further finishing can be eliminated. Get the facts on this new production-line material, available in sheets and in rolls. Send coupon today.

STEEL

and Steel Products

REPUBLIC STEEL CORPORATION
DEPT. C-3997
3150 EAST 45th STREET · CLEVELAND 27, OHIO

I'm interested in more information on:

- ☐ Republic ELECTRUNITE Mechanical Tubing
- ☐ Republic ENDURO Stainless Steel
- ☐ Republic Nylok Nuts
- ☐ Republic Continuous Galvanized Steel

Name_____ Title_____

Firm _____

Address _____

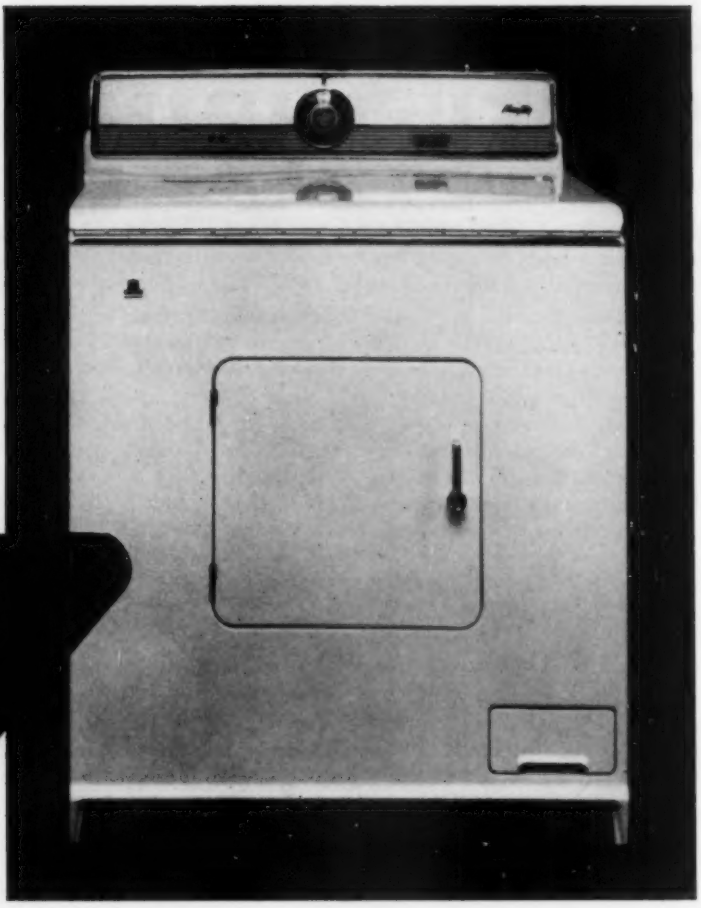
City_____ Zone___ State_____

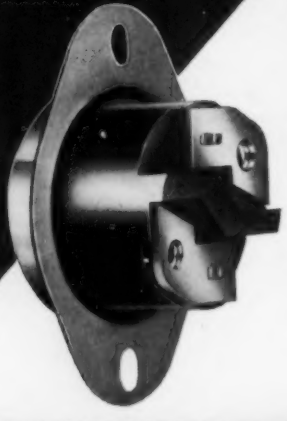
Maytag

continues to specify and use

KLIXON

Fixed Temperature Controls





in Newest Dryers

In designing their newest electric dryer, Maytag engineers retained an outstanding feature of previous models — the use of KLIXON snap-acting, fixed temperature controls. Here's how Maytag feels about these thermostats:

"In the past we have specified and used tens of thousands of KLIXON Snap-Acting Thermostats. We have found that they continually meet our standards of performance. We feel that KLIXON controls insure accurate temperature control."

You, too, can benefit from using KLIXON Fixed Temperature Controls. They are available in many sealed and open types in a wide variety of operating temperature ranges. Get full details on how KLIXON engineers, specialists in temperature control application, can help you. Write for THSN catalog sheets.

Typical KLIXON Fixed Temperature Controls used in many applications, including examples of the new 202 series for home appliances.

METALS & CONTROLS CORPORATION

Spencer Thermostat Division 3110 Forest Street, Attleboro, Mass.

KLIXON®

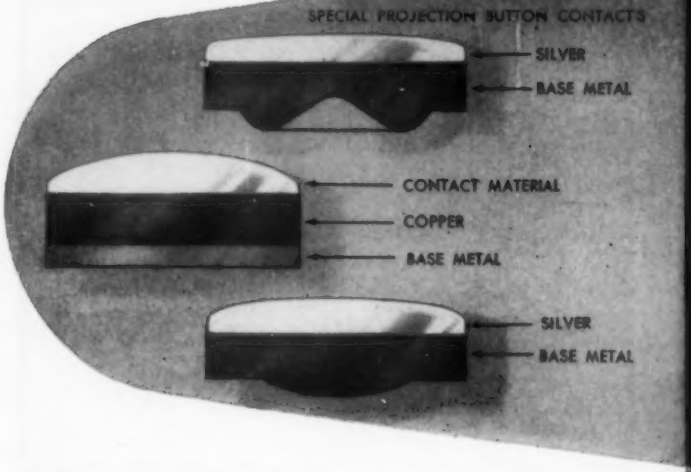
For Leadership
in Electrical Contacts Look to

GENERAL PLATE

Extensive new facilities are now completed and in operation at General Plate, offering customers a single source for an almost infinite selection of new and useful types and sizes of electrical contacts.

Here are but a few of the new ideas in contacts that have been developed commercially at General Plate.

- **Clad Electrical Contact Tapes** — designed for high speed mechanized assembly — ideal for miniaturization — give increased performance at reduced cost.
- **New Metal Bonding Processes** — offer improved contact materials — include silver cadmium oxides, refractory metal mixtures and platinum group metals, as well as all regular silver materials.
- **Trimetal Clad Projection Welding Contacts** — a copper conductor between contact face and backing — provides higher specific heat with lower surface temperatures — gives greater contact capacity and longer life at lower cost.
- **New Clad Button Projections** — designed and produced to meet your specific application requirements — facilitate easier welding, provide better conductivity.
- **New Silver Clad Rivets** — put silver where it is needed, with lower cost backing materials for better fastening properties.
- **Single and Double Inlay-Overlay-Top-lay** — made by G.P.'s new exclusive P.T. cladding process — achieves permanent bonding of preferred contact metals to practically any malleable base metal without intermediate bonding agents.



With 41 years of General Plate metal cladding experience behind the emphasis now being put on G.P. electrical contacts, it will pay you to investigate. Technical data bulletins are available on request — just let us know what types of contacts you are interested in.

You can profit by using General Plate metals

METALS & CONTROLS CORPORATION
General Plate Division
1010 Forest Street, Attleboro, Mass.
FIELD OFFICES: NEW YORK, CHICAGO, DETROIT, MILWAUKEE, LOS ANGELES

Engineering problem:

Pressure-tight fastening of transit cases

The solution:

A specially modified LINK-LOCK

Applied Design Company engineers worked with Simmons to develop this successful LINK-LOCK application

Simmons LINK-LOCK, with design modifications developed in cooperation with the Engineering Department of Applied Design Company, Buffalo, New York, resolves special closure requirements in rigidly specified transit cases like the aluminum equipment container shown.

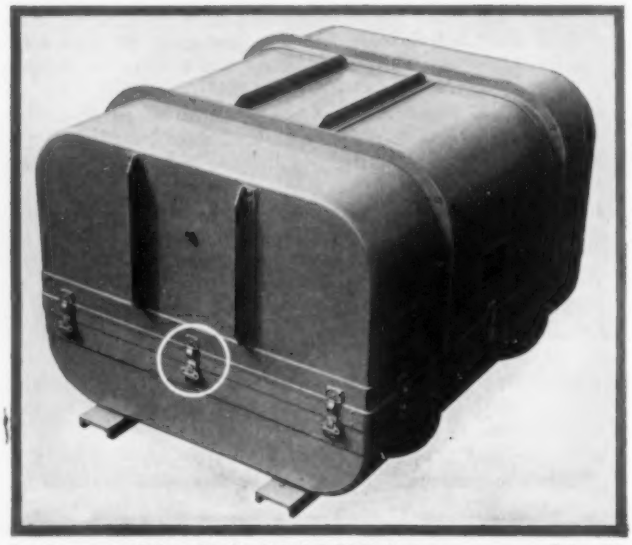
Here, the bowed LINK-LOCK engagement blade provides the double advantage of maintaining constant fastener pressure and permitting considerable mounting tolerance. This container is just one of many important products in which Applied Design specifies standard and special Simmons Fasteners.

Here's why LINK-LOCK is ideal for use on military cases produced to exacting specifications as well as on inexpensive commercial containers:

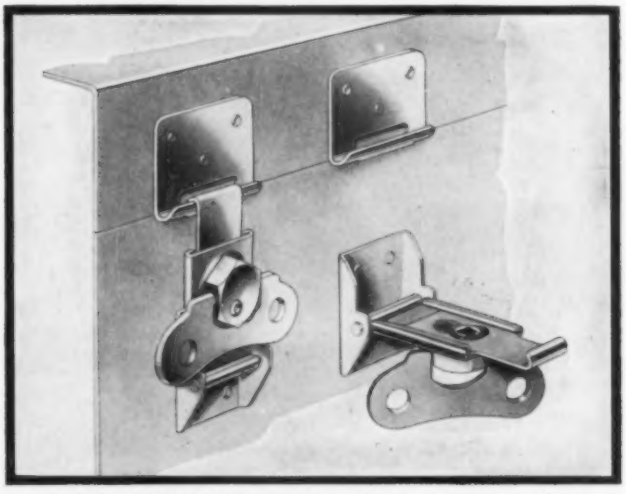
- Impact and shock resistant (positive-locking).
- High closing pressure with light operating torque... insures pressure-tight seals where required.
- Available in 3 sizes, for heavy, medium, and light duty.
- Compact design... lies flat against case even when unlocked.
- Opening and closing by wing-nut, screwhead, or hex nut.
- Flexible engagement latch design... can be varied to suit different conditions.

Also available: Spring-Loaded LINK-LOCK. Ideal for the less expensive containers where costs won't permit precision production. Spring provides take-up to compensate for set in gasketing, irregularities of sealing surfaces, and mounting inaccuracies.

SEND TODAY for the Simmons Catalog for complete information and engineering data on LINK-LOCK and other Simmons Industrial Fasteners. Engineering service is available; outline your particular fastening problems. Samples on request.



Twelve special loop-blade LINK-LOCK fasteners are used in this aluminum transit case designed by Applied Design Company.



Standard No. 2 LINK-LOCK (Medium-Duty). Available with screwhead, wing-nut as shown, or hex nut.

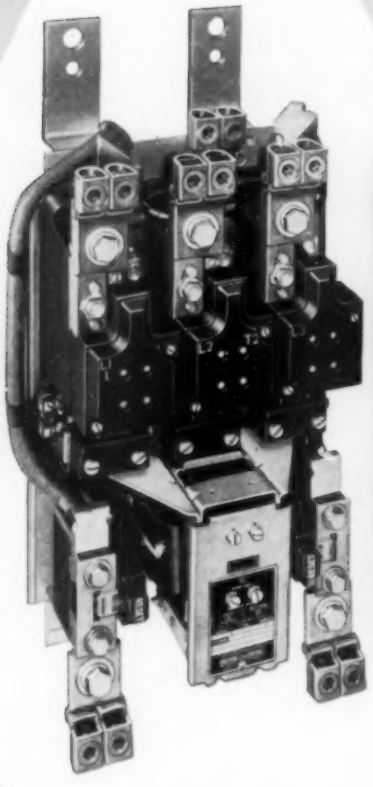
SIMMONS

FASTENER CORPORATION

1751 North Broadway, Albany 1, New York

QUICK-LOCK • SPRING-LOCK • ROTO-LOCK • LINK-LOCK • DUAL-LOCK • HINGE-LOCK

NEW



SQUARE D

Vertical Action SIZE 5 STARTER

Smaller! REQUIRES ONLY 270 SQUARE INCHES OF SPACE

DESIGN LEADERSHIP FEATURES IN SQUARE D's COMPLETE LINE OF VERTICAL ACTION STARTERS—SIZE 0 through 5

What's most important in a motor starter?

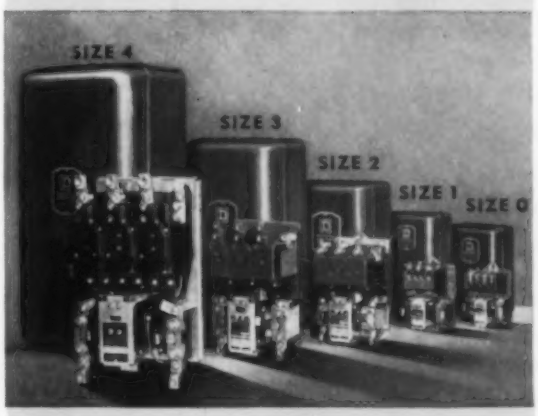
Performance and **long life** come first, naturally—and Square D's straight line guided motion and heavy-duty silver alloy contacts assure both. But that's only the beginning—

Fast wiring is important, too. Square D gives you a lot of wiring space and time-saving solderless terminals.

Easy maintenance rates high. The coils, contacts and overload relays on all Square D starters can be changed in a jiffy...without disturbing external connections. A screwdriver is all you need. And—

"Off-the-Shelf" Parts Kits make normal maintenance and "on-the-job" modifications easier than ever. Packaged parts include interlocks, contacts, coils, overload relays, pushbuttons and selector switches. They're easy to buy, easy to identify and faster to install.

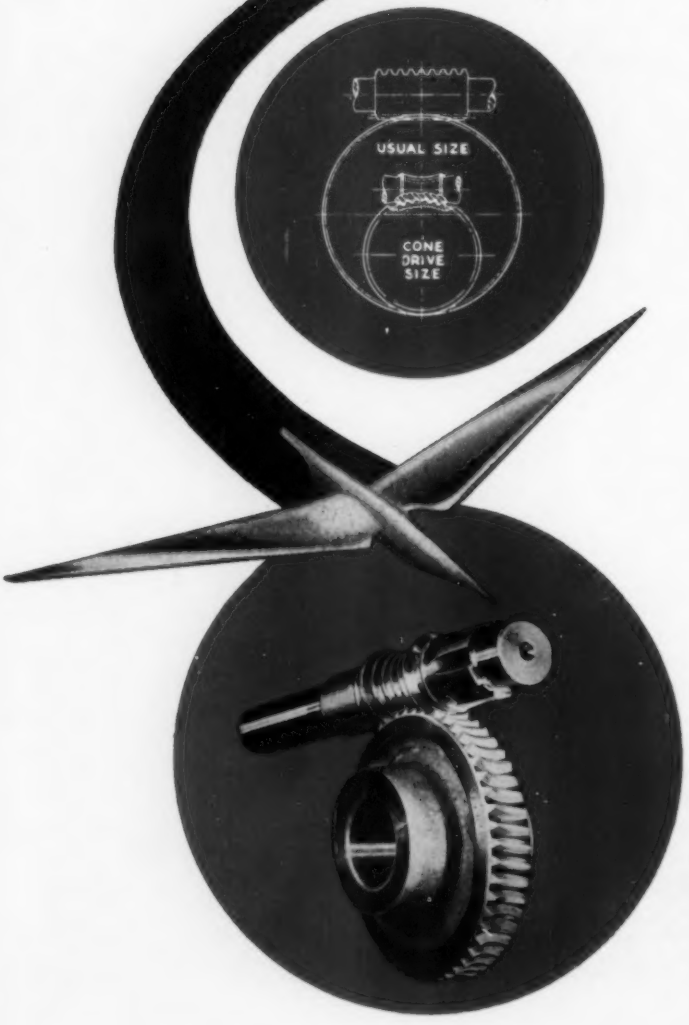
For the complete story, write for Bulletin 8536 Square D Company, 4041 N. Richards St., Milwaukee, 12, Wis.



EC&M HEAVY INDUSTRY ELECTRICAL EQUIPMENT...NOW A PART OF THE SQUARE D LINE

SQUARE D COMPANY

if you're looking for
smooth power



. . . CONE-DRIVE gearing has no equal.

You can drive the most delicate equipment or the heaviest industrial machinery without vibration or noise through a set of Cone-Drive gears.

Smooth delivery of power is an outstanding feature of Cone-Drive double-enveloping worm gearing. It's the result of a unique design that puts one-eighth of all gear teeth in simultaneous, full-depth contact with the worm threads.

The contact between teeth is "area" rather than the line or point type contact found in cylindrical worm gearing. This distributes the load over more area on each tooth to boost load-carrying capacity.

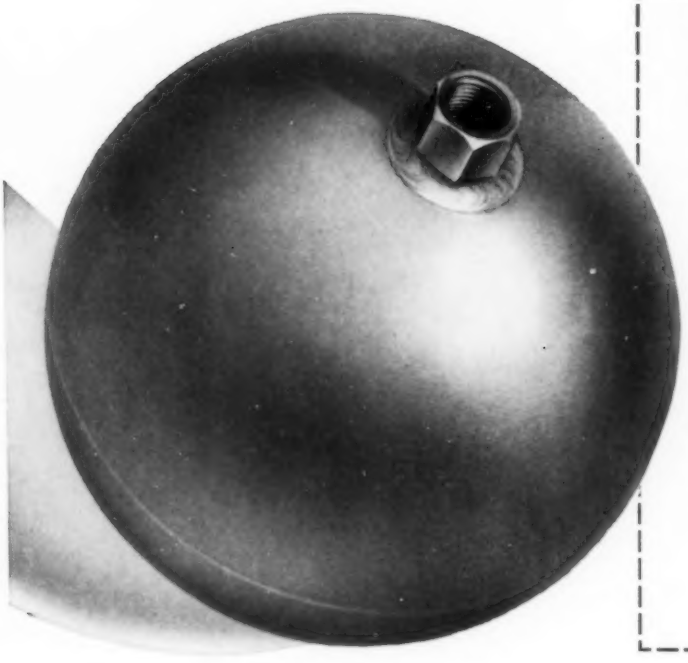
Want smooth, chatter-free, efficient power in a compact package? Cone-Drive gears will give it to you in gearsets or speed reducers in a wide range of models and sizes.

Ask for Bulletin 600-C for details.

CONE-DRIVE GEARS
A Division, Michigan Tool Company

DOUBLE ENVELOPING GEAR SETS & SPEED REDUCERS
7171 E. McNICHOLS ROAD • DETROIT 12, MICHIGAN

need floats?



Name the way you want them!

MATERIAL_____
SHAPE_____
SIZE_____
PRESSURE_____
QUANTITY_____
MORE INFO_____

*Your Name*_____
*Title*_____
*Company*_____
*Address*_____

See below for details

Fill in blanks, tear out, and mail to:

W. H. NICHOLSON and COMPANY
Wilkes-Barre, Pa.

Nicholson can deliver precision welded floats —made to your specifications—to fit your production schedule. Use the above form to tell us how you want them.

Here are the standard specs:

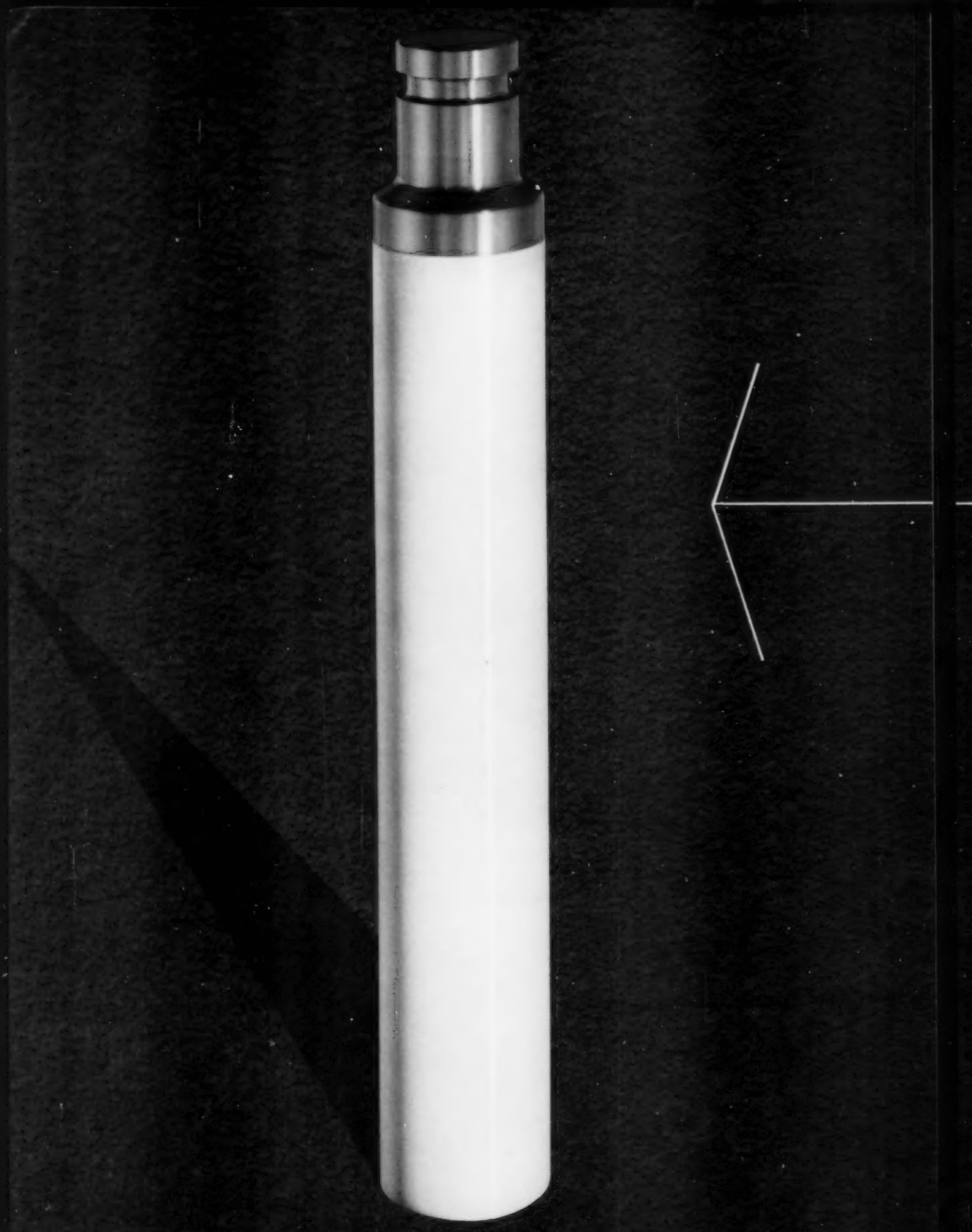
- **MATERIAL**—steel floats with chromium, cadmium or copper plating—with sandblast or pickled finish ... stainless steel and Monel floats—rough-buffed, polished or with welds ground smooth and highly finished.
- **SHAPE**—spherical, elliptical, cylindrical.
- **SIZE**—from 2 inches to 14 inches diameter.
- **PRESSURE**—from vacuum to 4800 lbs.
- **QUANTITY**—as many as you need.

These high tensile strength floats have exceptional resistance to pressure and corrosion. Float halves are die-formed, with inward rolled edges—not spun, laminated or electrodeposited.

Today, thousands of Nicholson floats are in service—most as buoyancy mediums . . . many as fluid chambers and pressure vessels. Write for details about the full Nicholson line.

W. H. NICHOLSON AND COMPANY, 12 OREGON ST., WILKES-BARRE, PA., *Sales and Engineering offices in 98 principal cities.*

NICHOLSON
of Wilkes-Barre



THIS IS A COORS HIGH STRENGTH ALUMINA CERAMIC PUMP PLUNGER, 4½" x 30", WITH AN AMCO-BRONZE PUMP-CROSSHEAD ADAPTER

Coors CERAMIC

...how it solves problems of abrasion and corrosion

IN RECIPROCATING PUMP PLUNGERS

Plungers for reciprocating pumps are an example of how design engineers are using Coors High Strength Alumina Ceramic to combat abrasion and corrosion. The applications vary from small chemical proportioners to oil field water flood pumps, operating under many different abrasive and corrosive conditions. For these requirements, Coors makes solid ceramic plungers in a latitude of diameters from ⅛″ to 6″ and in lengths up to 48″.

Because the material retains its high polish, longer pump packing life is assured. Also, in comparison to other ceramics, Coors has good thermal and mechanical shock resistance. Coors High Strength Alumina Ceramic has proved itself an ideal material for abrasive and corrosive applications, because it has a hardness greater than tungsten carbide, and resists all acids except hydrofluoric.

These properties enable pump manufacturers to stock only one material to cover a wide variety of abrasive and corrosive conditions.

MECHANICAL PROPERTIES

PROPERTY	UNIT	COORS Vitrified High Strength Ceramic TYPE AB-2
Tensile Strength	psi	17,000 - 18,000
Compressive Strength	psi	over 200,000
Flexural Strength	psi	42,000 - 45,000
Specific Gravity		3.40
Hardness	Moh's Scale	9
Maximum Working Temperature	°F	2550
Closest Machined Tolerances	inches	0.000020

DESIGN ENGINEERS — Coors High Strength Ceramic materials and Coors production facilities offer many product design possibilities to engineers where dimensional accuracy, corrosion, abrasion, and heat problems are a factor. For design details and complete mechanical properties, please refer to our 12-page catalog in Sweet's Product Design File.

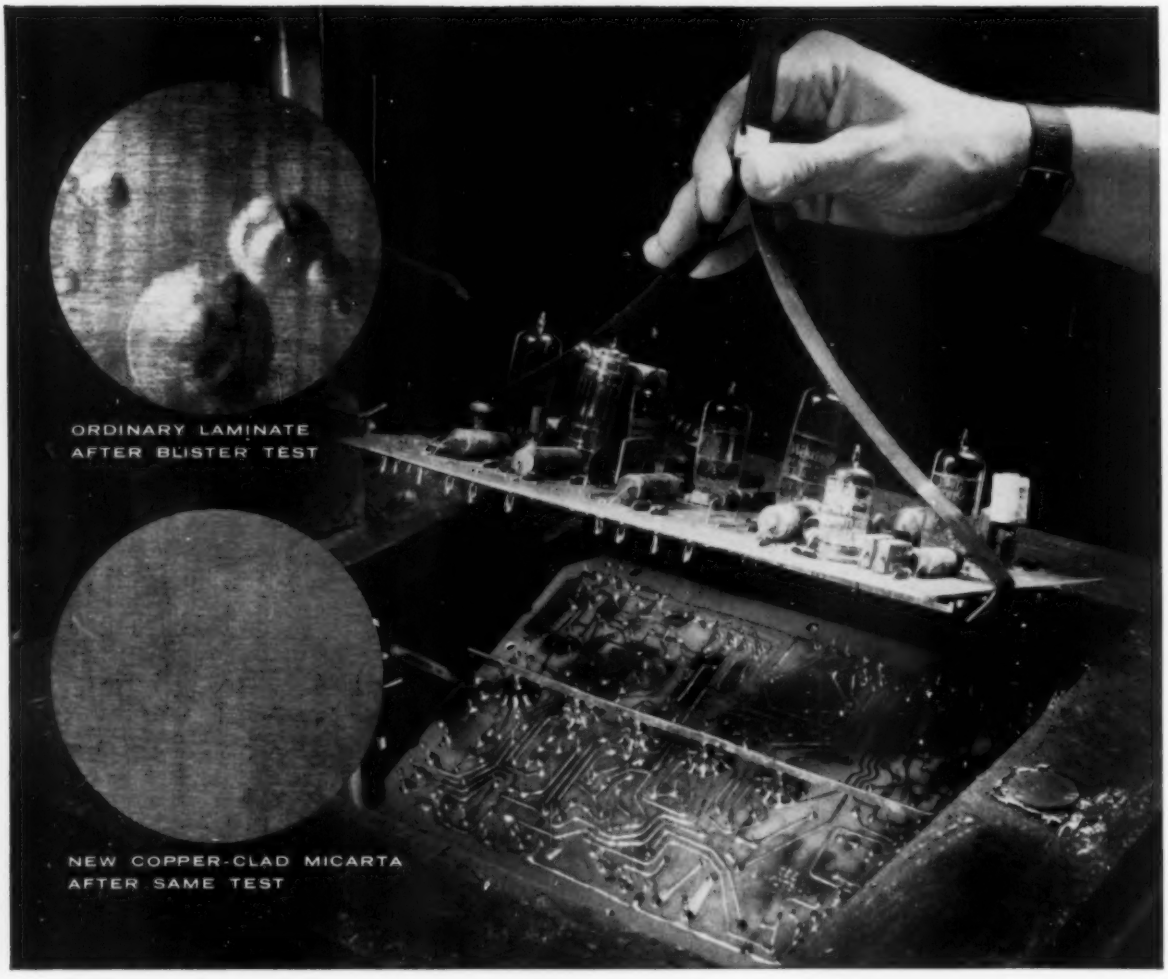
PUMP USERS — Coors High Strength Alumina Ceramic pump plungers may be obtained only from your pump manufacturer—some pump manufacturers stock our solid ceramic plungers.

COORS PORCELAIN COMPANY

Manufacturers of High Strength Alumina Ceramics

© 1957, Coors Porcelain Co.

Litho USA



New copper-clad **MICARTA®** takes dip solder bath without blistering!

New H-3032 copper-clad MICARTA® cuts costs and production time of printed circuits. Copper-clad MICARTA speeds up soldering, without the normal accompaniment of an increase in rejects and missed connections. It can be cold punched without cracking or chipping.

The laminate won't blister even when dip soldered for 10 seconds at 500°F! Examine the two close-up photographs. One shows an ordinary laminate after a laboratory test. Note the blistering, then look at the MICARTA dip soldered for the same length of time—and there is no blistering!

A special adhesive is used which has the same high electrical properties, solvent resistance and low moisture absorption as the MICARTA laminate itself. Actually, adhesive strength is increased during soldering.

Because of a new adhesive process, copper-clad MICARTA keeps its high bond strength—from 10 to 13 pounds versus an industry standard of six pounds—even after heating and cooling is repeated many times. This is especially valuable for electronic circuits.

Copper-clad MICARTA may be the answer to your circuit assembly problem. Write for further information and technical data to Westinghouse Electric Corp., MICARTA Div., Hampton, S. C.,

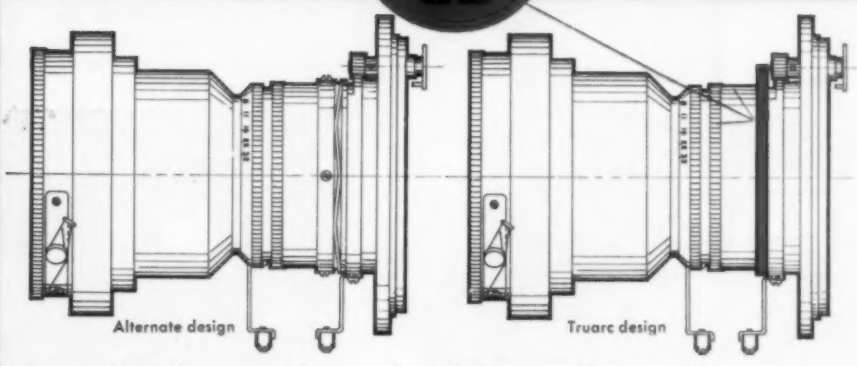
J-06624-X

YOU CAN BE SURE...IF IT'S Westinghouse

Waldes Truarc Retaining Ring eliminates 7 parts, saves $8.88 in sub-assembly of aerial reconnaissance camera

Gordon Enterprises, No. Hollywood, California, saved the Navy almost 1½ million dollars on 500 cameras. Gordon rebuilt new, efficient "CA" series out of Navy-owned obsolete models. Critical parts are now held together by Waldes Truarc Retaining Rings.

Truarc Rings are trouble-free, will not change position during operation. Accuracy is limited only by groove and ring dimension tolerances. And standardized Truarc Rings are quickly interchangeable in overhaul which now takes only 11 minutes, can be handled by unskilled technicians.



Truarc 5100-287 ring retains shutter speed adjustment mechanism on the Lens Adapter Plate Assembly which mounts and locks the lens and shutter assemblies accurately to camera body. Alternate design required retaining washer, spring, collar and 4 locking screws.

Weight Saving: 7.25 oz.

Assembly Time Saving: . . . . . 6½ min.

DOLLAR SAVINGS:

Material	**$ .93**
Fabrication	**6.88**
Inspection	**1.07**
Total	**$8.88**

Whatever you make, there's a Waldes Truarc Ring designed to save you material, machining and labor costs, and to improve the functioning of your product.

In Truarc, you get

Complete Selection: 36 functionally different types. As many as 97 standard sizes within a ring type. 5 metal specifications and 14 different finishes. All types available quickly from leading OEM distributors in 90 stocking points throughout the U.S. and Canada.

Controlled Quality from engineering and raw materials through to the finished product. Every step in manufacture watched and checked in Waldes' own modern plant.

Field Engineering Service: More than 30 engineering-minded factory representatives and 700 field men are at your call.

Design and Engineering Service not only helps you select the proper type of ring for your purpose, but also helps you use it most efficiently. Send us your blueprints today...let our Truarc engineers help you solve design, assembly and production problems...without obligation.

For precision internal grooving and undercutting . . . Waldes Truarc Grooving Tool!

WALDES

TRUARC®

RETAINING RINGS

WALDES KOHINOOR, INC.

47-16 AUSTEL PLACE, L. I. C. 1, N. Y.

Waldes Kohinoor, Inc., 47-16 Austel Place, L.I.C. 1, N.Y.
Please send new, descriptive catalog showing all types of Truarc rings and representative case history applications. *(Please print)*

Name _____

Title _____

Company _____

Business Address _____

City _____ *Zone* *State* _____

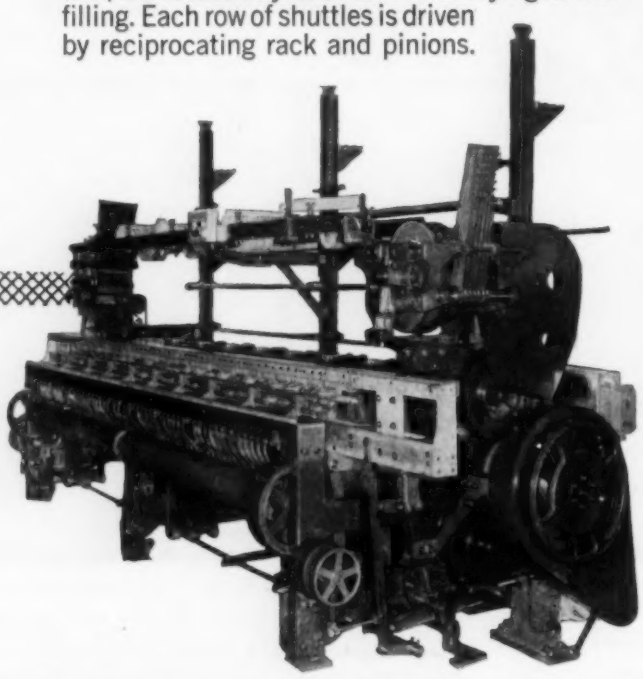
PN 109

WALDES TRUARC Retaining Rings, Grooving Tools, Pliers, Applicators and Dispensers are protected by one or more of the following U.S. Patents: 2,382,948; 2,411,426; 2,411,761; 2,416,852; 2,420,921; 2,428,341; 2,439,785; 2,441,846; 2,455,165; 2,483,379; 2,483,380; 2,483,383; 2,487,802; 2,487,803; 2,491,306; 2,491,310; 2,509,081; 2,544,631; 2,546,616; 2,547,263; 2,558,704; 2,574,034; 2,577,319; 2,595,787, and other U.S. Patents pending. Equal patent protection established in foreign countries.

HEIM *Unibal*

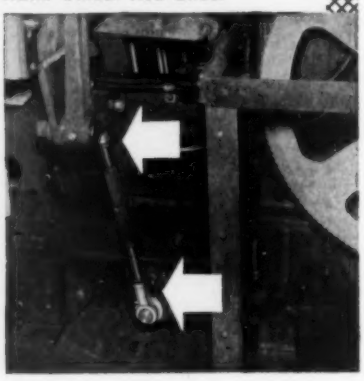
spherical bearing rod ends

In the production of narrow fabrics, the lay on the Crompton & Knowles Narrow Fabric Loom is driven back and forth from front to back, and the shuttles, arranged in two rows, top and bottom, move laterally back and forth laying in the filling. Each row of shuttles is driven by reciprocating rack and pinions.



are Necessary

To take care of inherent misalignments due to the backward and forward motion of the lay, and the lateral motion of the rack rods, **it is necessary to use HEIM Unibal Rod Ends.**



Correcting operating misalignment is just one indispensable feature of Heim Unibal. They have a greater surface supporting area, and are able to carry heavier axial and thrust loads. They reduce friction and lost motion, and eliminate brinelling. They are economical to buy, easy to install, and have a wide variety of uses.

THE HEIM COMPANY
FAIRFIELD, CONNECTICUT

Be sure you have the Heim Catalog showing sizes and load ratings

Send for a free sample so you can see for yourself this unusual, self-aligning Unibal principle.

Color in the Metal

Anodized aluminum finishes for sales magic and lasting beauty

The newest, brightest, most colorful metal isn't painted or plated . . . it's *anodized* . . . and aluminum is the only metal you can color anodize. It has the color *in* the metal; the color is made a *part* of the metal.

And the oxide film formed in the anodizing processes is really tough. Color-anodized aluminum won't chip, peel, crack or rust. It will stand up against corrosion and abrasion. It's bright, lustrous and lasting.

All of which is why you see more and more anodized aluminum grilles and trim on the new automobiles, and anodized aluminum parts in appliances and products of all kinds. Some of these parts are anodized in the "gleam of gold," some are clear-anodized for the "look of sterling," some are in gleaming colors. And *none* will rust—ever.

To add the glow of color to your products investigate the advantages of anodized aluminum finishes, where the color is *in* the metal. Complete information is given in Reynolds technical handbook, "Finishes for Aluminum", available when requested on business letterhead. For specific requirements, contact the people who know aluminum—Reynolds. Call the branch office near you, or write: *Reynolds Metals Company, P.O. Box 1800-HN, Louisville 1, Kentucky.*

Watch Reynolds All-Family Television Program "DISNEYLAND", ABC-TV.

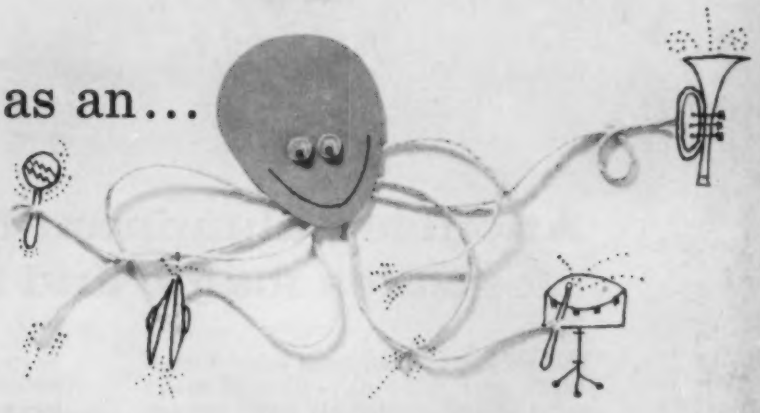
The Finest Products Made with Aluminum are made with REYNOLDS ALUMINUM

What's light as a...

strong as a...

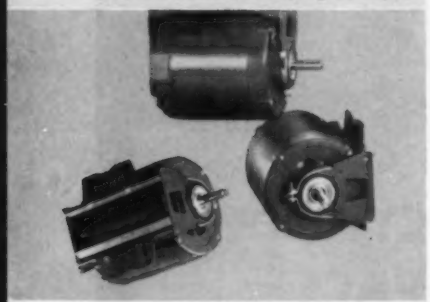
quiet as a...

versatile as an...

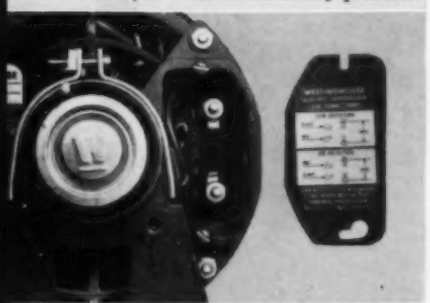


The 48·frame motor by Westinghouse!

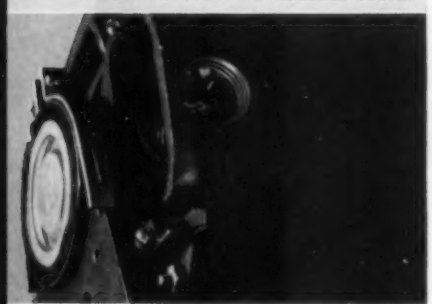
Light as a feather . . . by up to 50%!



Powerful . . . mounted in any position!



Versatile . . . modern terminal board!



Easy to mount . . . threaded conduit hole!

Dependable . . . because it's Westinghouse!

What do you look for in an FHP Motor?

Whether you are a manufacturer, designer, buyer or engineer, there are certain features you look for when you buy fhp motors. You want a motor that is light . . . powerful . . . compact . . . quiet . . . and long lasting.

These are just a few of the features you get in 48-frame motors by Westinghouse! Feature by feature, there are no finer motors on the market! Don't take our word for it . . . compare. Here are the facts . . .

Fact 1: The Westinghouse 48-frame is up to 50% *lighter* than motors of comparable power! For *you* this means lighter equipment, reduced shipping costs.

Fact 2: The Westinghouse 48-frame gives you *true* all-position mounting. Positive oil return system provides excellent lubrication in any position.

Fact 3: The Westinghouse 48-frame gives you spade mounting (plug-in), standard terminal stud connections, and shur-plug for changing rotation.

Fact 4: The Westinghouse 48-frame threaded conduit hole assures faster assembly on your production lines, fewer connector parts and *positive* connections.

Fact 5: The Westinghouse 48-frame *is Westinghouse!* This distinctive tag is your guarantee of quality, performance, and long life.

Want More Facts? Call your nearest Westinghouse sales engineer, or get your copy of the 48-frame booklet giving all the features in detail. Just fill out and mail this coupon . . . J-03034

YOU CAN BE SURE . . . IF IT'S

Westinghouse

Small Motor Division, Lima, Ohio.

WESTINGHOUSE ELECTRIC CORPORATION
Small Motor Division, P. O. Box 566
Lima, Ohio

Send me your 48-frame booklet.

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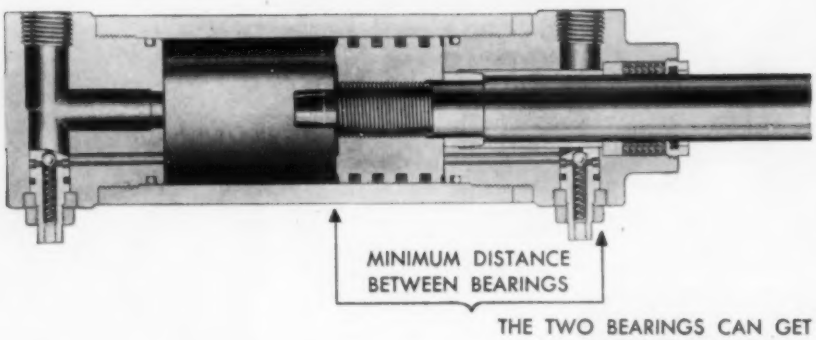

You Get These 5 Important Advantages:

1. Increased rod bearing life
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3. Reduced power eating friction
4. Eliminates rod cocking at end of out stroke, providing more rigid unit
5. Eliminates need for internal spacers

This space allowed between the two bearing points keeps the unit loading on rod bearings to a minimum. While we do not recommend extreme side loading of hydraulic cylinders when this condition is unavoidable, Pathon cylinders are best.

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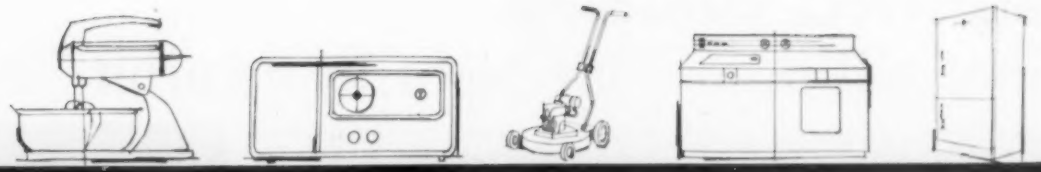

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Welding together sections for an earth satellite, under the most exacting specifications, may not be your particular problem. But if welding light-gage, hard-to-weld metals is slowing up your production—LINDE's HELIARC Inert Gas Shielded Arc Welding, using LINDE Argon as a shielding gas, may be just what you've been looking for.

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Get more information about HELIARC Welding and LINDE's other modern welding methods. For a free copy of the booklet, "Modern Methods of Joining Metals," address Dept. P-12, LINDE COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. *In Canada:* Linde Company, Division of Union Carbide Canada Limited.

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Shells of the Earth Satellite, Project Vanguard, are made of .050-in. magnesium alloy sheet, containing small amounts of aluminum and zinc. The two hemispheres are manually welded together (above), with a cover ring, by HELIARC Welding, a LINDE development utilizing an argon-shielded tungsten arc. Brooks & Perkins, Inc., are the fabricators.

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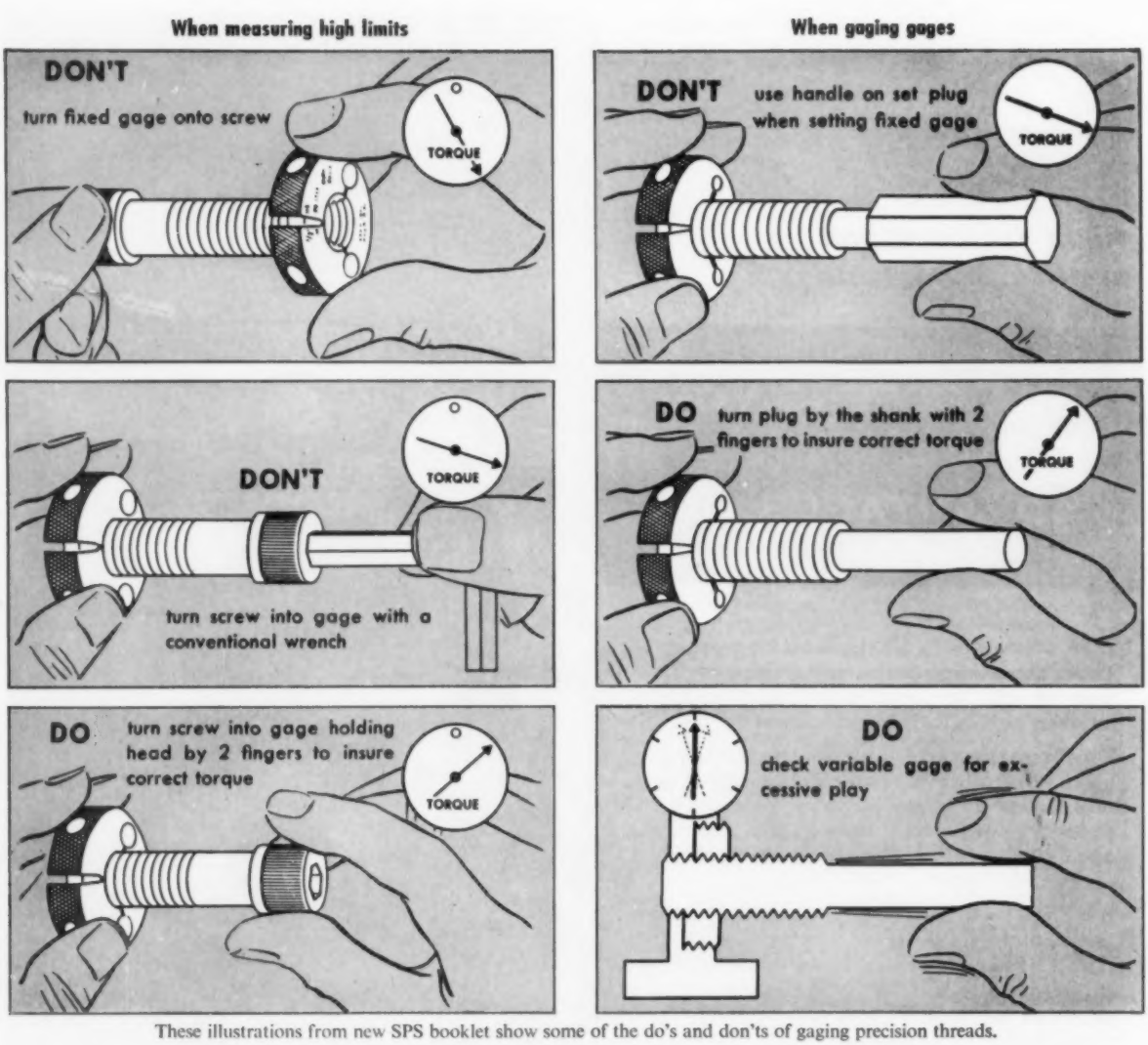

These illustrations from new SPS booklet show some of the do's and don'ts of gaging precision threads.

3A threads: what they are; how to gage them — new SPS booklet tells all

Threads made to Class 3A fit are the most precise in general use in industry. But you do not always get the 3A precision you specify. Because of many different gaging techniques that yield varying results, screws with threads well outside the Class 3A tolerance limits often pass inspection.

SPS has prepared a new booklet on this subject. It explains clearly what Class 3A threads are and the pros and cons involved in the widely varying gaging techniques in use today. It reviews the gaging of high and low limits of 3A threads, sampling techniques, and even the methods of gaging gages.

All standard UNBRAKO socket screw products fall within specified tolerance limits *no matter what method is used to gage them.* Leading industrial distributors carry complete stocks. Unbrako Socket Screw Division, STANDARD PRESSED STEEL Co., Jenkintown 28, Pa.

We also manufacture precision titanium fasteners. Write for free booklet.

Form 2239, "Class 3A Threads: what they are; how to gage them." 16 pages, with many illustrations. Write for free copy today.

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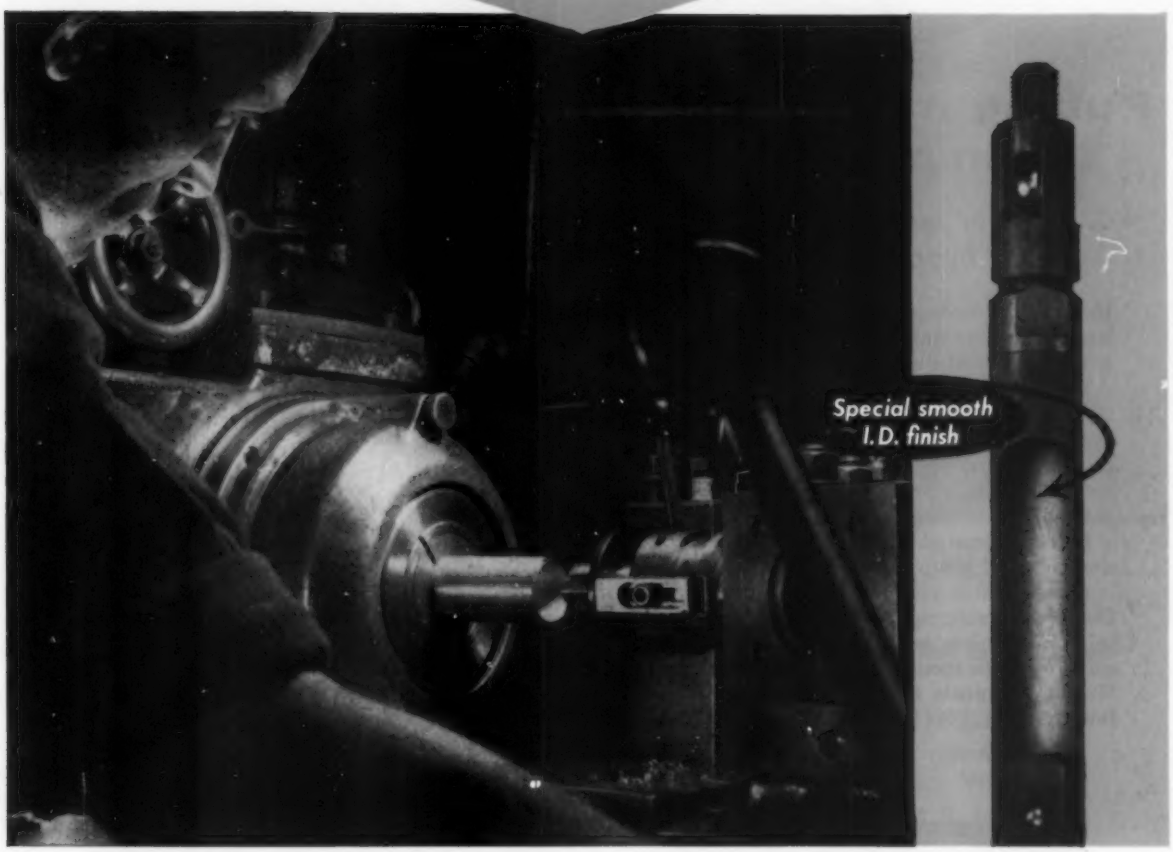
UNBRAKO® **SOCKET SCREW DIVISION** SPS

JENKINTOWN ■ PENNSYLVANIA

This pump manufacturer reports 25% savings with J&L COLD DRAWN ELECTRICWELD TUBING



Operator is threading 1¾" O.D. x 1½" I.D. J&L special smooth *cold drawn* Electricweld tubing for pump cylinder.

Low original cost and elimination of interior honing are two reasons why it pays you to specify J&L *cold drawn* Electricweld tubing with special smooth I.D. finish.

This manufacturer of oil well insert pumps reports a saving of 25% by converting from honed seamless tubing to *cold drawn* special smooth I.D. Electricweld tubing. Not a single tube failure has been reported from the field.

Because of its superior inside surface finish, exact tolerances and closely controlled physical characteristics, J&L *cold drawn* Electricweld tubing is recommended for these applications:

- *cylinder tubing* • *shock absorbers*
- *ordnance parts* • *hydraulic and pressure tubing*

J&L *cold drawn* Electricweld tubing is readily available in diameters from ¾" O.D. to 4¼" O.D., 8 gage to 20 gage, and can be furnished to closer than commercial tolerances. Write to Jones & Laughlin, 3 Gateway Center, Pittsburgh 30, Pa.

J&L STEEL

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... a great name in steel

How **DENISON** hydraulic power works for **LOGEMANN BROTHERS CO.**

Putting more squeeze in presses

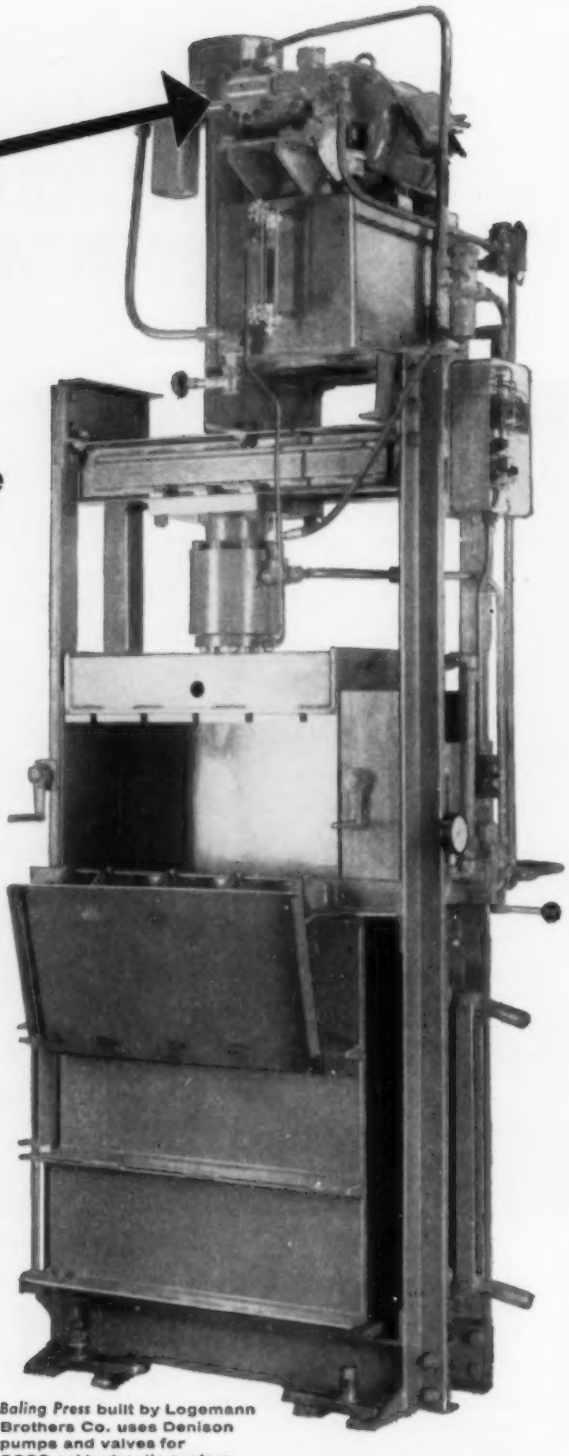
...another application for Denison hydraulic power

Here's how a leading manufacturer of baling presses assures peak performance for his product... combines it with dependability for long, continuous service.

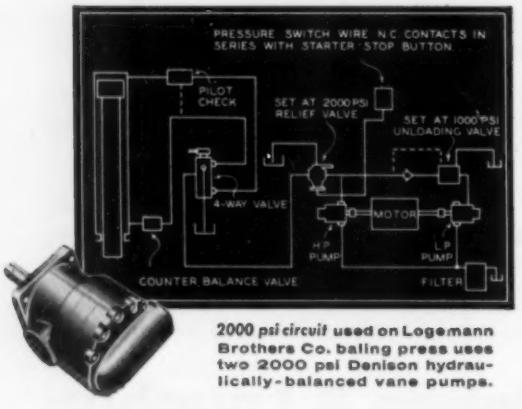
Power and speed of operation are achieved by the use of two 2000 psi Denison TMC balanced-vane hydraulic pumps. One Denison pump is set for 1000 psi for fast ram approach. The second pump is set for 2000 psi to provide necessary pressure for the power stroke.

By using identical 2000 psi pumps, maintenance is simplified and pump life greatly increased.

Endless design problems can be solved by using Denison hydraulic equipment on systems up to 5000 psi. Your Denison representative (who is an experienced hydraulic specialist) will gladly show you how. Write us. Denison Engineering Division, American Brake Shoe Co., 1194 Dublin Road, Columbus 16, Ohio.



Baling Press built by Logemann Brothers Co. uses Denison pumps and valves for 2000 psi hydraulic system.



2000 psi circuit used on Logemann Brothers Co. baling press uses two 2000 psi Denison hydraulically-balanced vane pumps.

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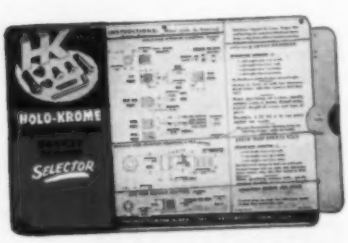
In the past two years, thousands of design engineers have written us requesting this H-K Selector. They know the H-K Selector is a valuable tool designed by engineers for engineers. When you need information at your fingertips to select the proper size and type of socket screw, you'll find the H-K Selector as handy as your slide rule. *It's yours free for the asking!*



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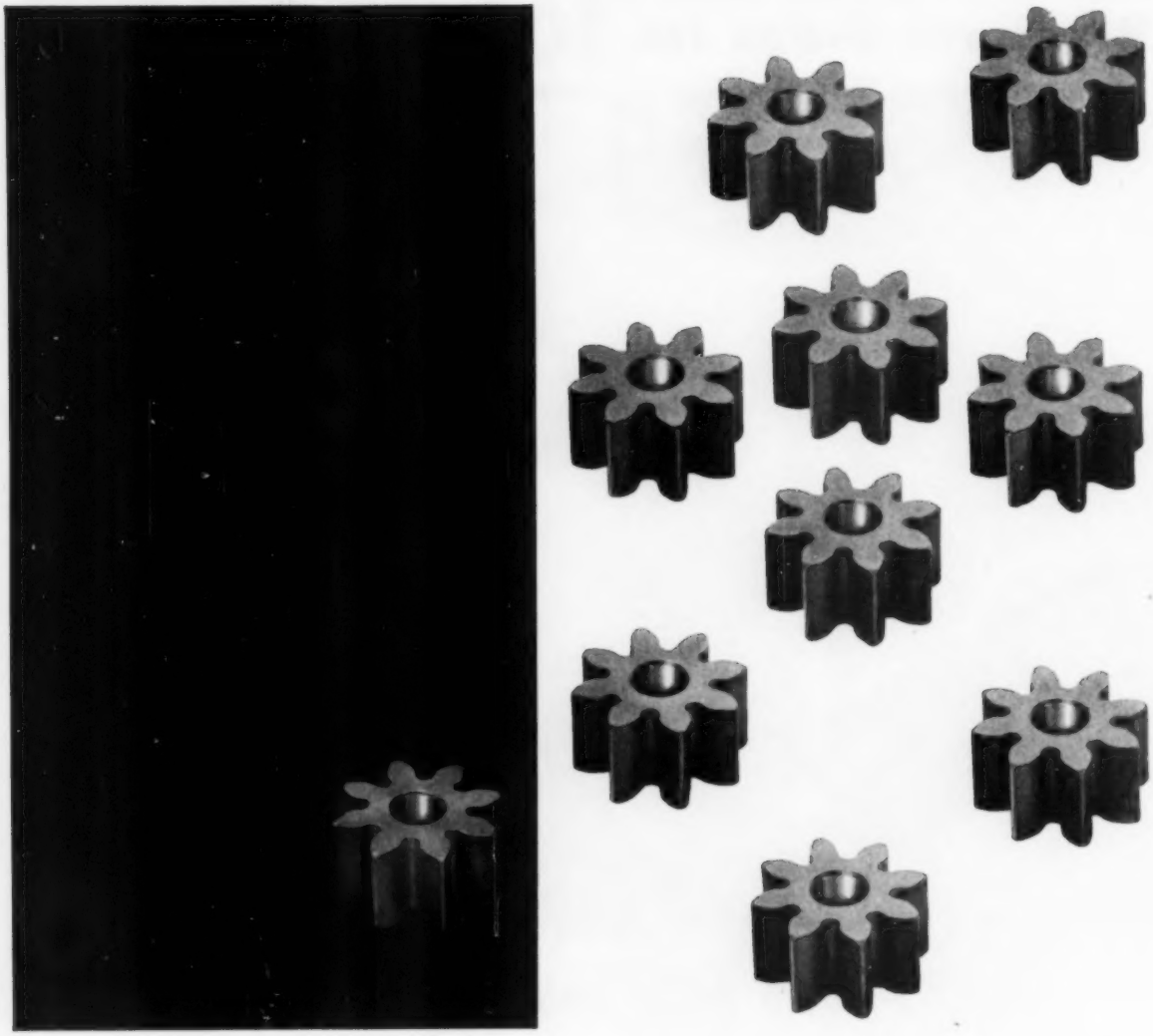

What about *wear* with metal powder parts?

Resistance to wear is an outstanding characteristic of the oil pump gears illustrated here. Moraine Products makes them of metal powder and holds them to exceptionally close tolerances. Gear teeth have unexcelled finish and uniformity. The result is dependable, quiet performance under any operating condition. For this application, as for so many others, long-wearing metal powder parts by Moraine Products have proved themselves to be the modern, economical answer.

Moraine Products also produces: Moraine Power Brakes • Delco hydraulic brake fluids, brake assemblies, master cylinders, wheel cylinders, and parts • Moraine friction materials • Moraine-400 and M-100 automotive engine bearings • self-lubricating bearings and porous metal filters • rolled bronze and bi-metal bushings.

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HERE'S self-alignment

IN A STEEL HOUSING

HOW "MILL BEARINGS" MAINTAIN ALIGNMENT. Spherical inner ring is free to align in any direction. Full load capacity is assured regardless of shaft deflection or misalignment.

"Mill Bearings" are available for shafts up to 11 inches.

SUPER-RUGGED CAST STEEL HOUSING. Cap is anchored solidly by extra large dowels and four heat-treated thru-bolts with serrated steel nuts.

LINK-BELT "Mill Bearings" with steel housings compensate for inaccuracies of welded and concrete support structures

HERE's one bearing really built to take the grind and grime of heavy loads in steel mills, mines, foundries and other extra-severe applications. The self-aligning Link-Belt "Mill Bearings" with cast steel housing adjust for misalignment of shafts and support structures. Furthermore, it eliminates the need for extra heavy shafting to avoid deflections which are ruinous to ordinary bearings.

This bearing is effectively sealed, self-contained, factory-adjusted—needs no shims or alignment rings at installation. Get full facts in Book 2565A . . . or Book 2550, which covers industry's most complete line of self-aligning ball and roller bearing blocks. Ask any of the 40 Link-Belt offices. 14,442-A

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self-aligning ball and roller bearings

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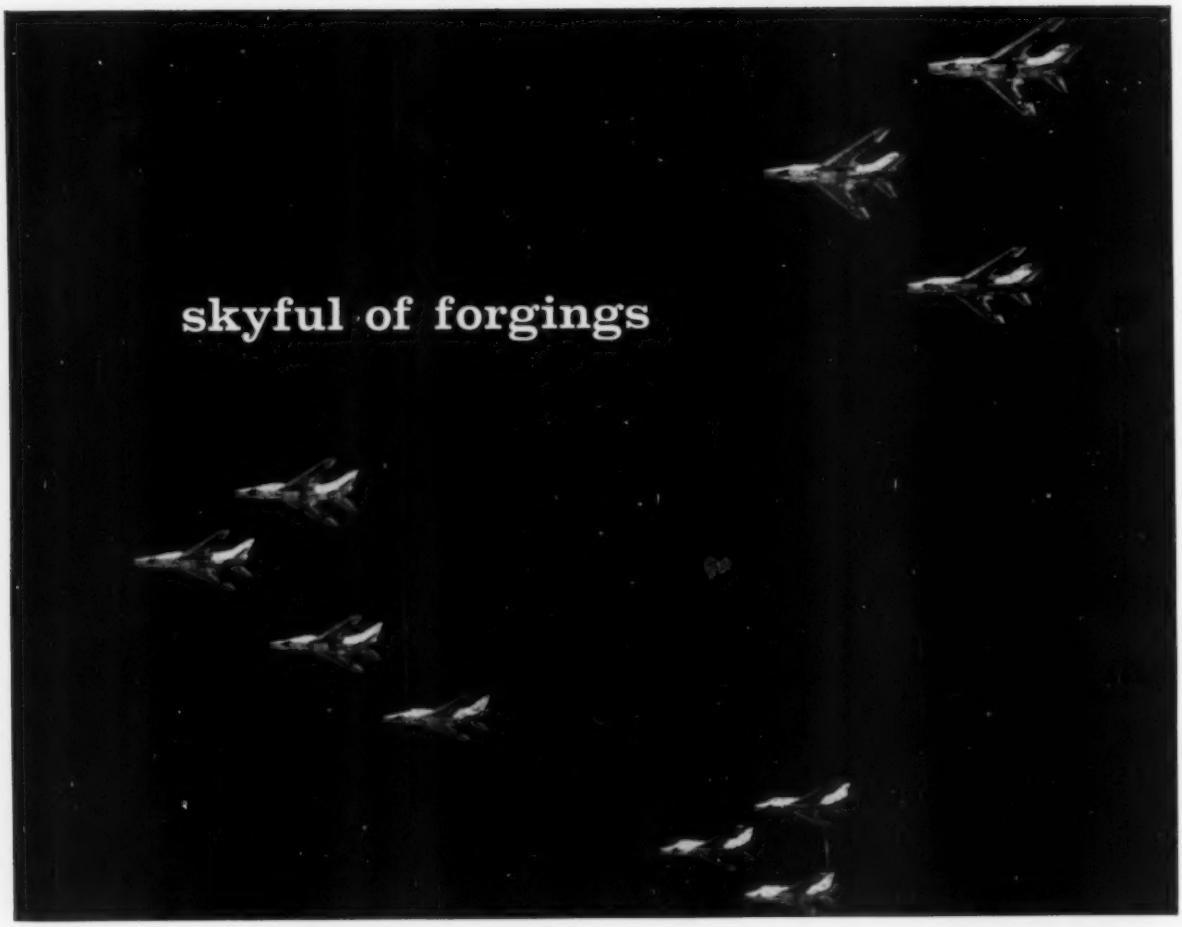


"Hot" aircraft are *really* hot today. High engine temperatures and the increasingly greater temperatures throughout aircraft structure are constant problems of high speed flight.

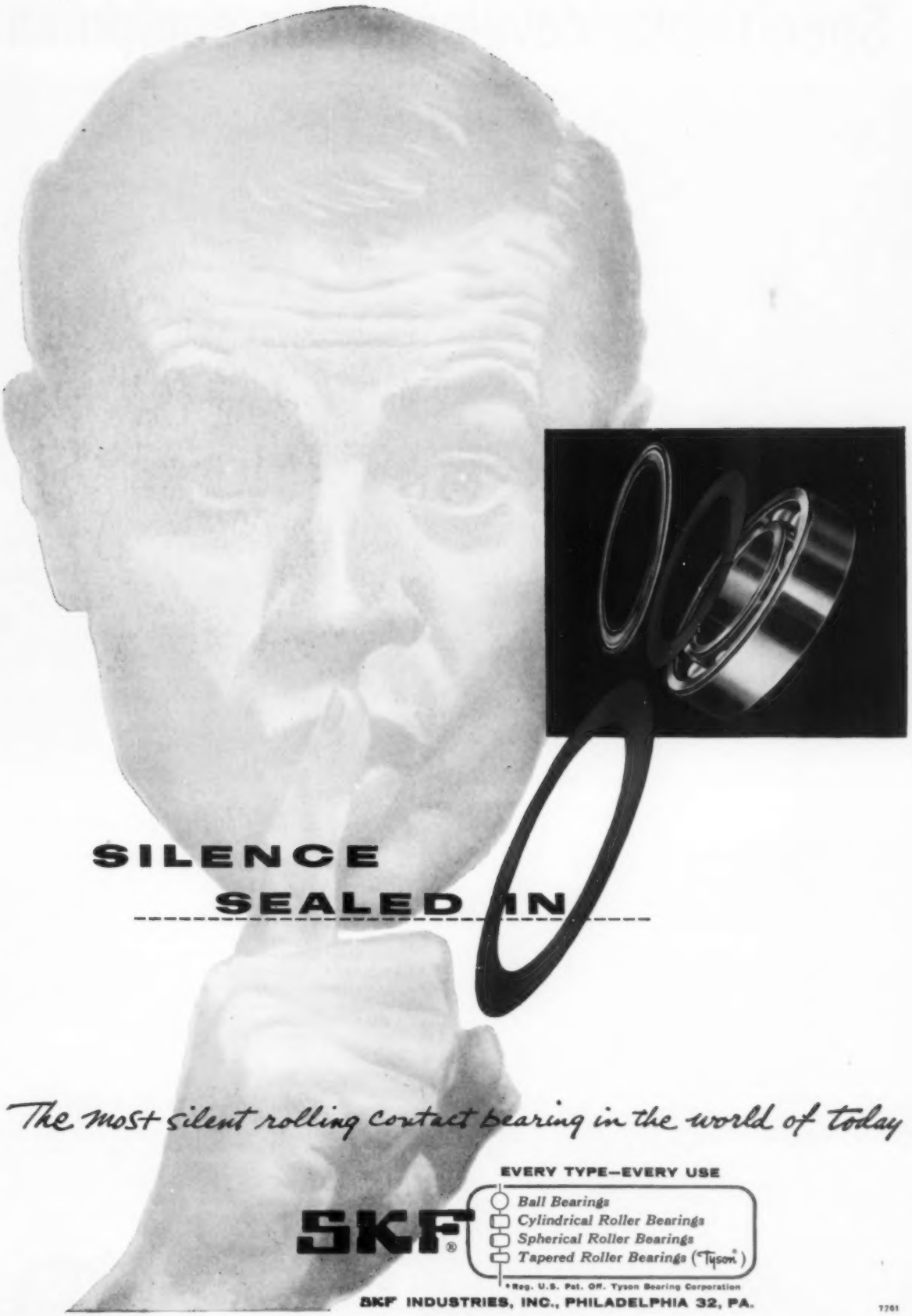
But forgings and fasteners of tough, heat resistant alloys are pushing back this "heat barrier", thanks to new metallurgical developments which greatly increase their forgeability and machinability.

Carpenter metallurgists have perfected a full range of these more-workable alloys for elevated temperature service. Forge shops, fastener-makers and engine builders find them always uniform, always on the "plus" side of strict aircraft specifications.

Design, application and fabrication properties of these Carpenter alloys are covered fully in our new booklet, "Carpenter Alloys for Elevated Temperature Service". A request on your Company letterhead will bring you a free copy promptly. The Carpenter Steel Company, 117 W. Bern Street, Reading, Pa.

Carpenter STEEL

Improved alloys for elevated temperature service



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Specifically developed for equipment

To obtain the strongest possible dipper handle

The dipper stick of this 6-cu.-yd. Lima power shovel is made of USS TRI-TEN Steel, hot-pierced and drawn into a tube, with 18" O.D. and 1½"-thick wall. Says the manufacturer, "We adopted USS TRI-TEN Steel to obtain the strongest possible dipper handle with the minimum of weight. A dipper handle is subjected to bending strain, as well as heavy impact loading, yet weight must be kept as low as possible since excess weight means the reduction of payload. Previously used ordinary steels did not stand up to hard usage."

20 cubic yards at a bite

This big-capacity Bucyrus Erie dragline bucket can scoop up 20 cu. yds. of overburden at one bite. It has to stand pounding far beyond the ordinary. That is why it was built with USS TRI-TEN Steel which ensures rugged strength and high resistance to impact and shock at any atmospheric temperature. The good welding and working properties of USS TRI-TEN Steel, even in the heavy thicknesses required here, greatly facilitate fabrication.

UNITED STATES STEEL
USS
HIGH STRENGTH STEELS
1933 1957
24 YEARS OF PERFORMANCE

that has to take it on the chin...

USS TRI-TEN High Strength Steel

THE PUNISHING ABUSE that today's heavy-duty earth moving and mining equipment has to withstand puts a high premium on durability.

Unless power shovels, draglines, trucks, bulldozers, scrapers and mechanized mining units have the rugged stamina to stay on the job under all conditions, day after day, the many thousands of dollars invested in them can easily become a losing proposition. Breakdowns, repairs and maintenance must be kept to a minimum. That's why USS TRI-TEN High-Strength Low-Alloy Steel is being increasingly used in the vital parts of such equipment.

USS TRI-TEN Steel has special properties that recommend it for applications where maximum ruggedness, toughness, strength and endurance—*combined with minimum weight*—are of prime importance.

An outstanding advantage of this steel, and one that will be appreciated by every equipment user who has been plagued by part breakage during severe cold spells, is USS TRI-TEN Steel's ability to withstand impact shock at sub-zero temperatures.

Not only is USS TRI-TEN Steel very tough but it is very strong as well. Its yield point of 50,000 psi min.* is 1½ times that of structural carbon steel and is combined with a tensile strength of 70,000 psi min. in thicknesses of ¾" and under, with moderately lower values as thicknesses increase up to 4". TRI-TEN Steel, too, has greater resistance to abrasion than structural carbon steel. It has twice the resistance to atmospheric corrosion. Its fatigue resistance is 50% higher. And its cost is low.

In addition, USS TRI-TEN Steel has good weldability and excellent workability, important factors that help to cut costs in fabrication and repair work. Our 174-page "Design Manual for High Strength Steels" will guide you in applying USS TRI-TEN Steel most efficiently and economically. Write for your free copy—on your company letterhead, giving your title or department—to United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

**Still higher strength can be obtained with USS "T-1" Steel—a constructional alloy steel that offers a yield strength of 90,000 psi min. and tensile strength of 105,000 psi min. combined with weldability and tremendous toughness.*

To absorb the grief of heavy duty

Used in the Minnesota iron ore mines, the entire interior surface of this 24-cu.-yd. Heil dump truck body is of USS TRI-TEN Steel. The floor is 1"-thick plate, sides and front are ⅜" plate. Experience on the Iron Range has proved that TRI-TEN Steel provides the strength and toughness necessary to withstand severe impact and loading shocks even in the coldest weather. And it does this better and more economically than many more expensive grades.

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USS HIGH STRENGTH STEELS

USS MAN-TEN • USS COR-TEN • USS TRI-TEN

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UNITED STATES STEEL

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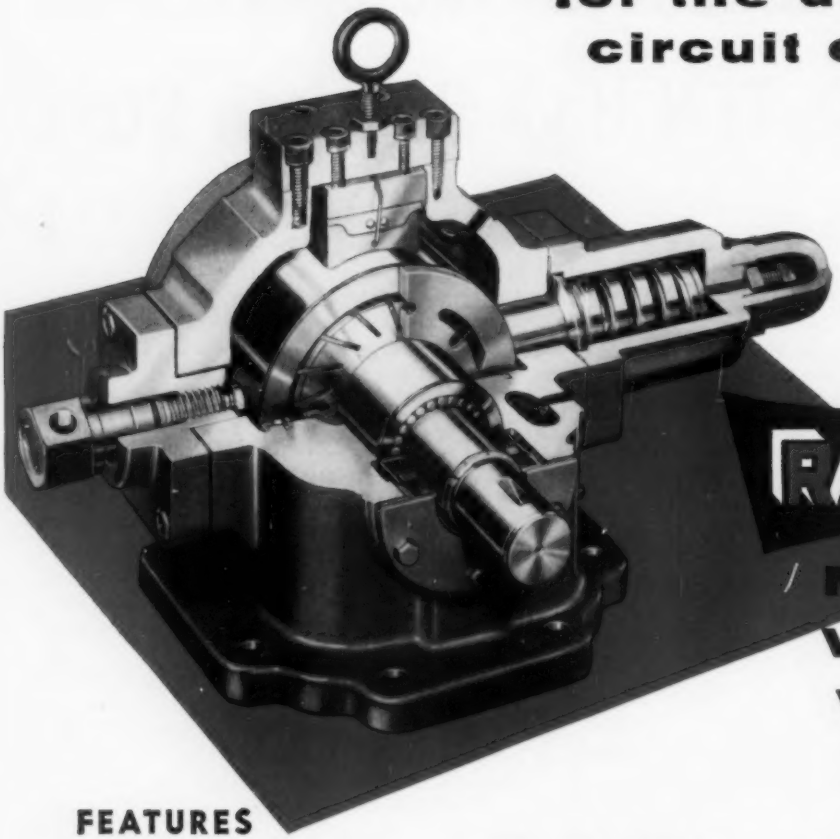
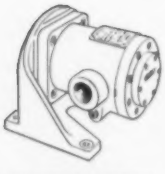


New RACINE® Model R Variable Volume PUMP

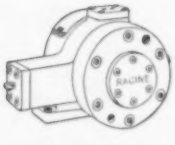
FEATURES

- **VARIABLE VOLUME DESIGN** simplifies the circuit. Relief valves with extra piping are eliminated.
- **AUTOMATIC BUILT-IN GOVERNOR** regulates volume of oil delivered to exact requirements of circuit. This feature reduces heat and saves horsepower.
- **VARIOUS BUILT-IN GOVERNORS** are available for electric, hydraulic or manual operation. Where needed, two pressure governors are provided.
- **THIS PUMP** is subplate mounted, result is simple installation and ready maintenance. Machine downtime is reduced.
- **DESIGNED FOR 40 GPM** maximum volume with built-in control to regulate flow to lower volume. Operating pressure 1000 PSI continuous duty, 1250 PSI intermittent duty.
- **SALES AND SERVICE OFFICES** in all industrial centers throughout the country. Write today for *new* fully descriptive bulletin.

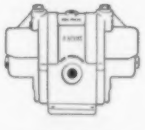
OTHER RACINE HYDRAULIC COMPONENTS **"THEY WORK BETTER TOGETHER"**



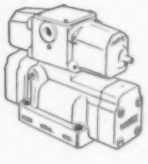
FLUID MOTORS



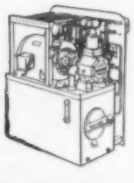
Model Q Variable Volume PUMPS



PRESSURE BOOSTERS



4-WAY VALVES



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WANTED / *A way to wash all clothes automatically*

DELIVERED / *A Packard two-speed motor*

Either you wash light and heavy clothes differently, or you run the risk of ruining the delicate fabrics, or letting the heavy ones remain half-clean.

Mechanical speed-changers can help you solve this problem. But they're complicated, cumbersome and costly. However, until Packard Electric stepped into the situation, that was all there was.

Then, by working closely with washing machine manufacturers, and by drawing upon years of motor development and production experience, Packard Electric produced the first two-speed electric power unit for washers. It had just the right amount of speed, power and torque. And it gave Packard's customers a competitive plus that's being talked about throughout the industry.

Packard Electric's research, engineering and production teams have a long record of accomplishment in making custom-built motors work better in appliances. We'll help you solve special design problems, then deliver your motors complete with mountings and accessories to simplify your assembly procedures and lower costs. Investigate this opportunity now.

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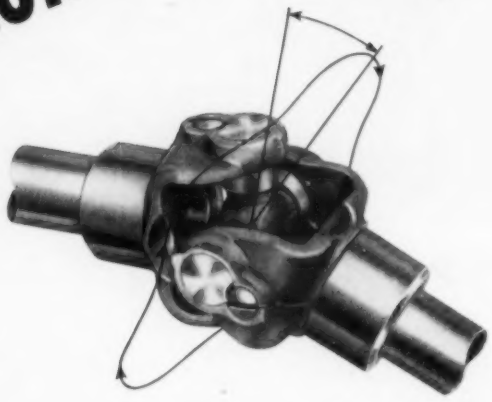
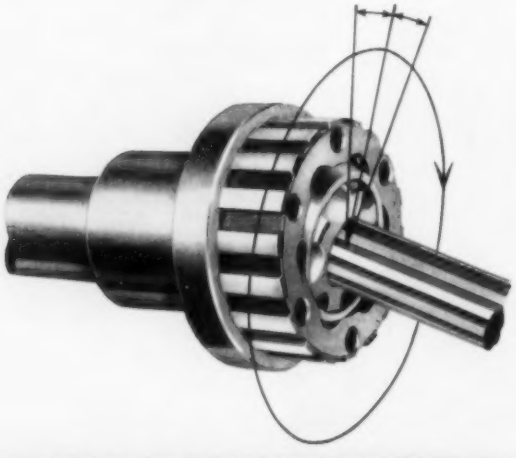
Warren, Ohio

Division of General Motors

RZEPPA JOINTS ELIMINATE THE HIGH COST OF "Rock and Roll" Action...



Old-fashioned pin or slipper-type joints speed up, slow down twice during one revolution. What you get is rough and tumble "rock and roll" torque which cuts down joint life, causes vibration.



RZEPPA (PRONOUNCED "SHEPPA") CONSTANT VELOCITY JOINTS ELIMINATE THIS "ROCK AND ROLL" ACTION FOREVER!

Rzeppa Joints transmit 100% smooth torque every minute they are on the job. Operate precision smooth at angles up to 35°. No bounce. No chatter. No vibration. Long life and higher torque capacity are built into every Rzeppa Joint. You get longer shaft life, too.

RZEPPA ("SHEPPA") CONSTANT VELOCITY UNIVERSAL JOINTS

THE GEAR GRINDING MACHINE CO.

3939 Christopher, Detroit 11, Michigan

MANUFACTURERS OF: FULLY AUTOMATIC GEAR GRINDING MACHINES. DETROIT SCREWMATIC 750 SINGLE SPINDLE SCREW MACHINES.

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SEND FOR LATEST BROCHURE

—or send us a dimensional sketch along with peak horsepower, operating angles and R. P. Ms. Our engineers will assist in making a proper joint recommendation.

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The *economical* way to make your products strong, light and handsome is with Revere Aluminum Sheet. Economical because aluminum is so easy to handle and process, can so readily be given a surface finish of distinction.

Revere can serve you promptly now from plants in the East and Mid-West, and soon will be fully integrated as a primary aluminum producer. Revere Copper and Brass Incorporated. Founded by Paul Revere in 1801. Executive Offices: 230 Park Avenue, New York 17, N. Y.

Revere Aluminum Mill Products include coiled and flat sheet, both plain and embossed; circles; blanks; Tube-In-Strip; extruded products; seamless drawn tube; welded tube; rolled shapes; electrical conductors; forgings; foil; frozen food containers. Write for new illustrated booklet on Revere Aluminum Sheet. Free!

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the versatile

DLM BRAKE

offers greater flexibility... dependability!

The revolutionary DLM brake will serve effectively with a variety of equipment. It has already proved its value as a control or parking brake, and is used in various sizes on trucks, busses, machinery, farm equipment, cranes, shovels, hoists, golf buggies, lift trucks.

Highly Efficient! The DLM brake is basically a self-energizing two-shoe brake in which both shoes are more efficiently utilized to produce the same amount of work—give equal forward and reverse torque output, regardless of drum rotation.

Simpler! Only 8 parts, with interchangeable shoes and springs. Lubrication is not required. No internal adjustment necessary. Enclosed design guards against entrance of foreign matter and requires only a minimum of maintenance.

Lighter! More Payload Advantages! Improved Timken-Detroit design using lightweight fabricated steel shoes and brake supports saves many pounds over heavier, more costly brakes.

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BRAKE DIVISION
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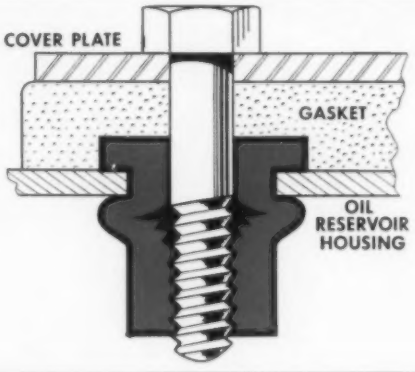
For every industrial, agricultural or automotive application where braking is required!

B.F.Goodrich Rivnuts

cut assembly time and costs by 50%



ELIMINATE WELDING, TAPPING AND CLEANING

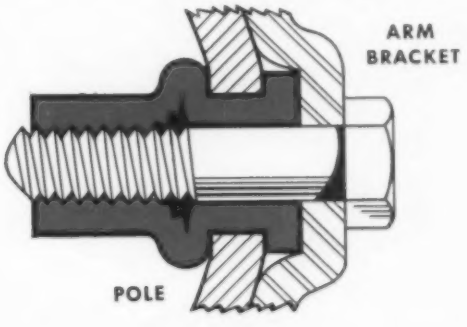
A fastening job on oil reservoir housings formerly took 5 operations. First the housings had to be detoured from the assembly line. Then nutplates were welded on the inside, drilled, tapped and cleaned before the covers could be attached.

By switching to B. F. Goodrich Rivnuts, this whole job is now done in half the time. Rivnuts are installed by one man from one side, in seconds. They provide firm, accurate nutplates with six clean threads for fastening. Flow of assembly is uninterrupted.

ONE MAN NOW DOES THE WORK OF TWO

Using conventional nuts and bolts, it took two men to fasten the arm bracket on street light poles. Now, with B. F. Goodrich Rivnuts, one man does this work in the same amount of time.

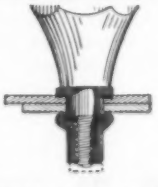
In the factory, one worker installs Rivnuts in the aluminum poles simply, quickly. The assembler in the field merely lines up the brackets, slips the attachment bolts into position and tightens them. As for strength, tests show that the pole or arm bracket will fail before the Rivnuts.



Rivnuts provide at least 6 clean threads in one simple operation!

1 Rivnut is threaded onto pull-up stud of a manual or pneumatic heading tool.

2 Rivnut is inserted—head firmly against work — tool at right angles to work.



3 Tool lever operates pull-up stud, forming a bulge in the Rivnut shank.

4 After upset, Rivnut threads are still clean and intact ready for screw attachment.

SEND NOW FOR FREE RIVNUT DEMONSTRATOR

Demonstrates with motion how Rivnuts fasten *to* and *with*. Explains construction, gives proved applications. Write to *B. F. Goodrich Rivnuts, Department PE-107, Akron, Ohio.*

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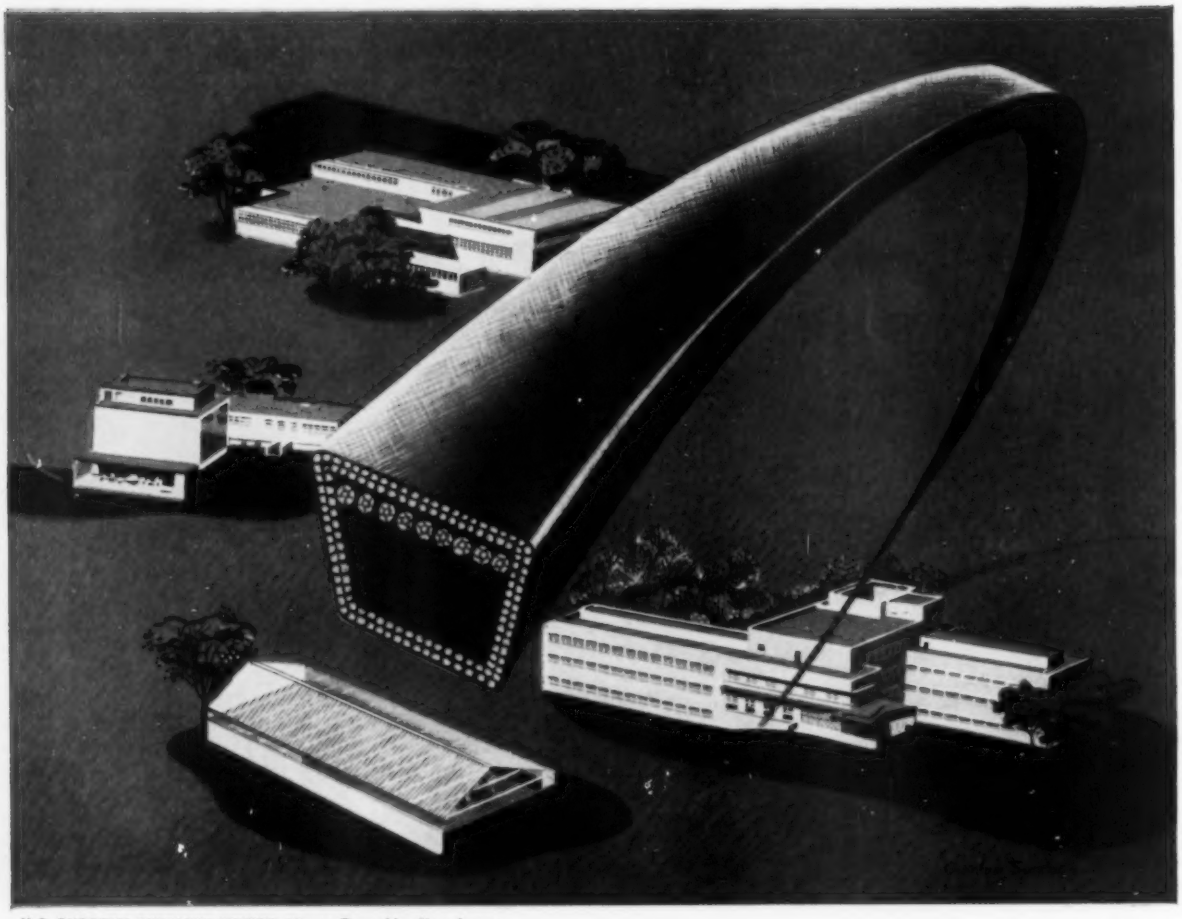
UNITENSION V-BELTS



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A New Place for Creating and Perfecting...

Since 1846, we have created many things... created the products you need to increase output, cut costs.

We have done our thinking in a lot of places, but we like our newest place best of all.

Our Research Center in Wayne Township, New Jersey, will be the source of the Mechanical Goods that have always been United States Rubber Company's especial pride. The new Center will be staffed by men who work and live in the heritage of those who produced, for example, our Unitension V-Belt.

Every cord in this unique belt is built in by error-proof electronic controls, instead of the commonly-used mechanical means. This guarantees that each cord will pull its full share of the load, thus, belt life is prolonged. This precise control of manufacture results in elimination of vibration. Unitension® V-Belts free you of the problem of matching. They are made by a process that results in a *uniformity* unattainable with any other method. The Unitension belt is but one of the many developments that germinate in our research staff. Their aim is to make things *better*.

The unparalleled facilities, equipment and convenience of this largest and newest Research Center in the rubber industry constitute a source of inspiration, excitement and greater vision to our scientists and engineers. From them will come rubber goods that will far surpass the performance of today's products and render to industry services never dreamed of before.

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See things you never saw before. Visit U.S. Rubber's new Exhibit Hall, Rockefeller Center, N.Y.

PERSPECTIVES

in design and development . . .

Engineers Here And Abroad

Picking up where we left off in the Sept. 16 issue, here are reports on the manpower situation from five more countries. Perhaps noticeably absent in the previous survey was a report from England, which arrived too late for that issue. It leads off here in the second installment of this survey. Reports on several south-of-the-border countries appear in the News pages of this issue.

England

The engineer shortage in England, currently assessed as between 10 and 16% for most industries, shows peaks in several fields. For chemical engineers it is placed as high as 50% by some manufacturers. Next come mechanical engineers with a 20% shortage; then electrical engineers, physical chemists and metallurgists, in that order.

Many firms here claim the shortage has only marginal effects on current R & D projects, for the larger groups already have trimmed their research targets and maintain that most of the vacancies have been filled. The exception, as in other countries, is in the atomic energy field, where many R&D programs have been handicapped. The principal need here is for metallurgists—there are only 3,200 in England—and physical chemists.

"Underemployment" at the top is another problem, with an even greater shortage of men to relieve the professional engineers of detailed work. A spokesman for one large company said the standard of draftsmen has become deplorable in recent years. England employs 78,000 engineers of a degree status (0.6% of a 24-million working population), and there are only 30,000 other workers with any lower, though useful qualifications.

The supply at the university level has improved in quantity but not quality. Flow of engineers from universities is presently running about 5,000 per year and will reach 6,000 by 1958-59. But by this time, industry's requirements will have increased 30% from 78,000 to 100,000. Consequently, many companies have been forced to use graduate training methods for students coming directly from grammar schools. Metropolitan-Vickers now has 2,700 such trainees out of a total of 26,000 workers.

The distribution of engineers, now badly influenced by glamor and status ratings, has aggravated the situation. Worst hit are the heavy electrical and power plant people. "You can neither keep nor attract graduates into this field because of the attraction of the electronics business." Also, there has been a migration from long-established firms on a purely geographical and social basis, particularly when the slightest financial gain is promised. A graduate can now expect an annual salary of $2,100 to start; and, by his late thirties settle for $3,600 if not too smart, and $5,100 if brilliant.

Of the percentage of qualified engineers to people employed in any industry, the oil industry tops 5%; the chemicals have 2.7%; and all others have less than 2%. Shipbuilding and automobiles, the two largest industries in England, have less than one-half of one percent.

The shortage of mechanical engineers throughout England is con-

(Continued on page 63)

Classic decorated porcelain simulated for the first time in

NEW MELAMINE Schlitztap

NEW "SCHLITZTAP" consists of three melamine parts – handle collar, color band, and decorated section. These are assembled on a threaded aluminum rod and held between an anodized aluminum shank and crown. This striking draught-beer sales aid stands a handsome 12" high, carries two gay, five-color village street scenes. It looks like the finest bone china.

"Fused-in" decorations now possible on complex shapes, says Chicago Molded... and here's how it's done:

The design and production of the beautiful new "Schlitztap" is the result of more than two years of intensive research by the Jos. Schlitz Brewing Co., and by Hammer Bros., Inc. A solution to the complex problems involved in molding the tap handles was provided by Chicago Molded who engineered and molded the plastic parts.

A milestone in plastics technology, the "Schlitztap" represents the first time that a compound curved melamine surface has been decorated on a production-line basis. And with this type of decoration, the design is fused right into the melamine. It's virtually indestructible—immune to perspiration, scratching, staining or chipping.

Paves way for new applications. Most important, the "Schlitztap" represents a breakthrough for plastics into the field of decorated ceramics. It suggests parts ranging from decorated containers and giftwares, to lamp bases and door knobs—all made of beautiful, break-resistant melamine.

How it's done. Among the technical molding problems overcome by Chicago Molded was appearance of bubbles on the decorated surface, mottling of colors, and "burning out" of the pastel tones. Using a dual cycle operation, each piece is molded in a horizontal position on a 170-ton transfer press. During the first phase, melamine is forced into the die and allowed to pre-cure. The mold is then opened for positioning of two melamine foil overlays. Then there's a final curing cycle and the decoration becomes an integral part of the completed handle.

Whatever your plastic molding needs, you'll find it pays to call in Chicago Molded. CM engineers keep abreast of the progress in plastics, often *create* that progress to help you make your product more saleable. *That's why 66% of our business comes from firms we've served for over 20 years.*

For your free subscription to Plastics Progress, CM's magazine on up-to-date developments in plastics, write today to:

CHICAGO MOLDED
PRODUCTS CORPORATION
1032 North Kolmar Avenue, Chicago 51, Illinois

sidered the most serious. One of the major causes is the emergence of thermodynamics as a major subject. Being the least specialized in any one particular engineering skill, but usually familiar with the theory and practice of many of them, the mechanical engineer has been absorbed in nonmechanical work. More are being lost to the production side. Sales staff also takes more personnel with degrees.

No one seems alarmed yet at the pirating of engineers. Worst offenders are the smaller firms that do not have the rigid salary scales of the larger groups. Consequently, when they want a man, they can pay his price.

The belief is that engineering in England will not be considered a glamor field until England's public schools become more convinced of the merits of an engineering career.

India

The shortage of technical manpower for research and industrial projects is gradually decreasing from the acute situation in 1951. But the supply of qualified and experienced engineers for design, research and planning still falls far below demand.

In 1947, India had only 28 engineering colleges, admitting annually 2,900 students for civil, mechanical and electrical engineering. There were then 50 technical institutes training 3,700 young high-school graduates for 2-year courses. Since the date of Independence (Aug. 1947), the engineering schools have increased to 80. They enroll 6,300 students each year. The number of technical institutes has increased to 123, enrolling 8,800 students annually. For chemical engineering, there are three institutes, each enrolling annually about 135 students. So far, India has only one institute for postgraduate courses in engineering for 570 students. The prestige of engineering as a career has advanced greatly.

Annual starting salary for a graduate is about $810, exclusive of allowances. If the applicant for the job has foreign training, he can get up to $2,500 from a large company in mechanical or electrical engineering.

By 1961, India is scheduled to have three more institutes for postgraduate work. One is being set up with Russian aid under a UNESCO program, and will be staffed by 15 Russian professors teaching chemicals, textiles, radio and electronic engineering. West German specialists will man a second institute, and US aid is hoped for the third institute.

Both governmental project administrations and private engineering firms have, in their agreements with foreign firms, a clause for training most members of their staffs abroad. So far, 113 civil, 258 mechanical, 241 electrical, 43 mining, and 21 chemical engineers, and 119 metallurgists have been recruited for Russian- and British-aided plants, the consultant for which is a German combine of Krupps-Demag. So far, 90 Indians have been trained in Russia, 68 in Germany, 300 are scheduled for England, and 900, under the Ford Foundation's plan, are in the US.

Philippines

With the exception of the mining industry, there is no over-all shortage of engineers here. The Philippines is in the ironic position of having some young engineering graduates working as common laborers, while new industrial ventures are desperately looking for specialists to help solve the problems of expansion. Industries like textiles, plywood, paper and pulp, food processing, and ceramics must go abroad for their specialists. Small industries depend for this help upon governmental agencies such as the Industrial Development Center.

There is a demand for all types of engineers, despite the fact that there are engineers not working at their trade. This demand is for qualified men,

(Continued on page 65)

NEW MODELS WITH NEW FEATURES
new advanced engineering . . new styling . . . new "Crown Control" for Choke-Speed-Stop.

(Illustrated is the Crown Model 88-H – 2¾ hp with Crown Control)

Briggs & Stratton 4-cycle engines are No. 1 in use throughout the world

YEAR after year, more equipment for home, farm and industry is powered by Briggs & Stratton 4-cycle engines (to 9 hp) than by any other make.

This overwhelming acceptance is based on the proven record of Briggs & Stratton engines for dependable, trouble-free, long-life performance.

Put this engine acceptance — this demand — into the equipment you're designing. And — to save board time, money and modification headaches — you're invited to utilize Briggs & Stratton's consulting engineering service.

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Briggs & Stratton Corp.
Milwaukee 1, Wisconsin

WORLD LEADER, TOO, IN AUTOMOTIVE LOCKS, KEYS AND RELATED EQUIPMENT

and it will take several years of industrialization before most of the younger engineering graduates have the necessary practical experience to fill most of the jobs in new and untried (in the Philippines) industries.

Chemical engineering is the field which is in particularly short supply, but the university is moving to correct this situation. Today there are less than 100 mining students enrolled, with at least 100 more needed in industry. The US government is presently sending six to eight university engineering instructors per year to the States for 12 to 18 months of postgraduate work.

A qualified project or design engineer with the government, in a job requiring supervisory responsibility, draws about $300 per month, while those with industry get 50% more. Newly graduated engineers start at $90 to $125 per month.

Finland

There are not enough engineers in Finland, and the situation will get worse unless the state produces money to build new educational facilities. There is no significant difference in the spread of this shortage among companies of different sizes. However, the large establishments suffering most are the state-owned firms offering salaries that cannot compare with those of private concerns. In an equally bad position are the local government authorities, for similar reasons. Finland is highly socialized, and this hits the railroads, power stations, power construction companies, most road construction, airlines and big engineering firms.

Effect of the shortage on research programs is small, since there are not many firms that can undertake research on a large scale. In state-owned establishments, the effect on research is readily apparent, again because of the low salaries. The supply of different types of engineers is currently under study; but in general there are no great differences in the various branches—excluding new fields like nucleonics, and some electronics.

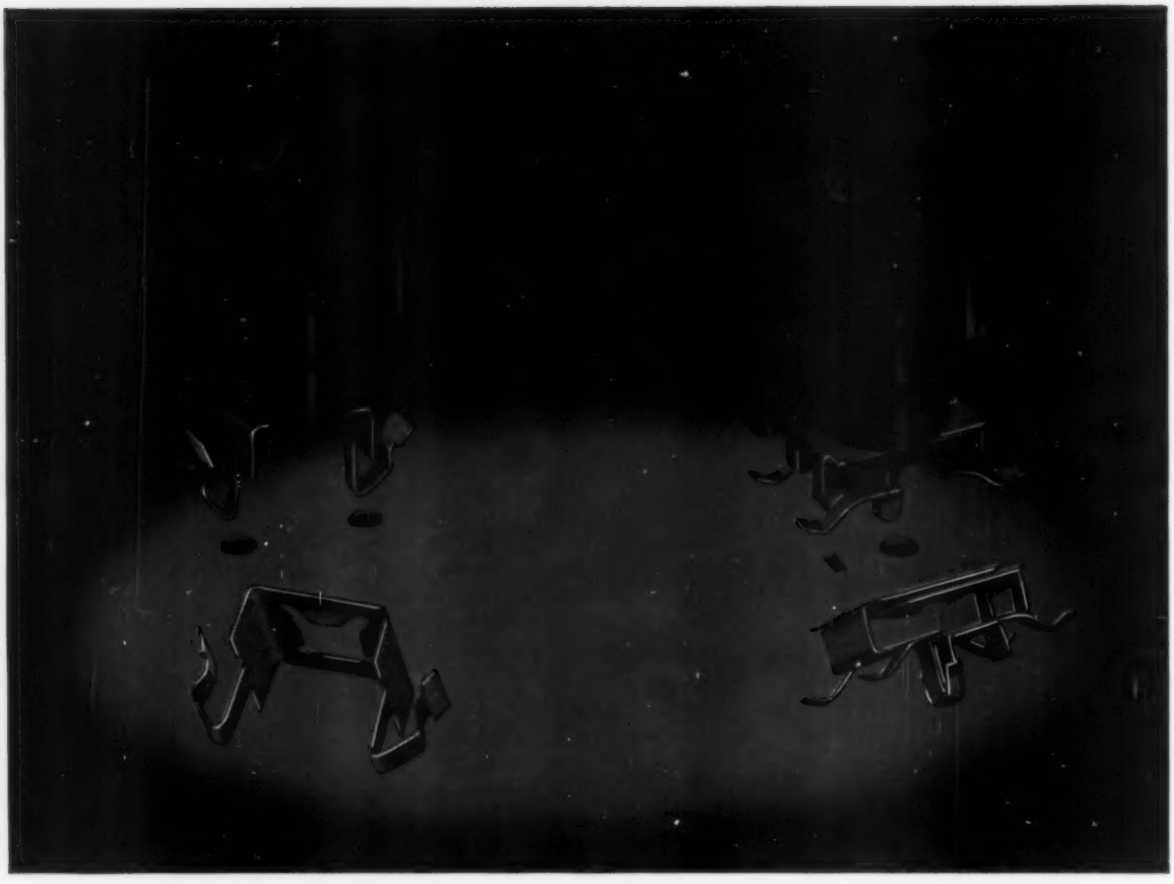
Starting salary directly after graduation is about $220 per month; about five years later, $350; at about age 40, $450. These dollar values are computed at the official rate of exchange ($1=231 Finmarks) which is lower than the officially recognized tourist rate of exchange—($1=325 Finmarks).

Denmark

Engineering is a prestige job here; so much so that the number of students who want to enroll in technical universities far exceeds the educational capacity. Even so, considering the supply of professional engineers and engineering technicians per million inhabitants in European countries, Denmark is surpassed only by Norway, Sweden and Austria. Still, there is a shortage of engineering manpower throughout Danish industry. A major contributing factor is that about 15% of the engineering manpower is working abroad, either for Danish export firms or for foreign companies. Because of a low level of industrial investments, Danish production has been low for the last few years. To some extent, this has curtailed the home demand for engineers, and helped avoid an aggravated unbalance. At present, the shortage is most acute in electrical engineering, with chemical engineering in about the same straits. Supply is more evenly balanced for mechanical and civil engineers.

Average yearly income of a professional engineer with two years' experience is about $3,200 according to the official conversion rate from the Danish crown to the dollar. But allowing for the purchasing power of a dollar, that $3,200 is almost doubled in value.

—Paul Anderson



Engineered by Tinnerman...

On the assembly line...and in the field plug-in **SPEED CLIPS**® simplify rectifier installation

At General Electric, two variations on a single SPEED NUT® principle are being used to make things easier for production-line assemblers and for electronics servicemen.

The basic idea of the Tinnerman front-mounting SPEED CLIP is incorporated into the sockets of GE germanium rectifiers made by GE's Semiconductor Products Department, Syracuse, for industrial electronics applications.

On the TV production line, the Tinnerman SPEED CLIP permits rapid, tight, and simple installation of rectifiers. In the field, merely by unplugging the original equipment rectifier and plugging in its germanium replacement, the serviceman can quickly get a unit back in service.

Working together, General Electric and Tinnerman engineers developed the two types of SPEED NUT parts that are fabricated right into the rectifier shells.

Unusual applications of the SPEED NUT principles to scores of different products are developed every day at Tinnerman. That's why over 9,000 different forms of SPEED NUT Brand Fasteners have been designed for all leading manufacturers.

Your fastener problem can probably be solved quickly by a call to your Tinnerman sales representative. If his name isn't in your telephone directory, write to:

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FASTEST THING IN FASTENINGS®

CANADA: Dominion Fasteners Ltd., Hamilton, Ontario. GREAT BRITAIN: Simmonds Aerocessories Ltd., Treforest, Wales. FRANCE: Simmonds S. A. 3 rue Salomon de Rothschild, Suresnes (Seine). GERMANY: Mecano-Bundy GmbH, Heidelberg.

Product Engineering

October 14, 1957

Watch the Bellwethers

The driver who goes on a long trip without a road map and an eye on signposts will travel too far and too long. The farmer who doesn't watch the weather will go broke. The technician who doesn't keep an eye on the gauges will sooner or later lose control.

The designing engineer must likewise keep a weather eye open for trends, for ideas, for the latest developments—or his designs will be obsolete before they are off the board. But there are so many telltales, so many sources, that sorting out the important and reliable ones is as hard as picking the winner before the race.

The answer is to watch the bellwethers. In most design, three important ones are aircraft, automotive, and machine-tool developments. Many ideas developed in these three industries are later applied elsewhere.

For years, Metalworking's bellwether has been the automotive industry; now aircraft is looming as a more important one. This implies no loss of initiative on the part of the automotive industry. That industry has, in recent years, pioneered in automation, in standards for electrical and hydraulic circuits, and more recently in "building-block" machine-tool design. But the emphasis is on quantity—on high-production equipment with high obsolescence rate, and the product is designed with this in mind. Not too many other industries or companies can think in similar terms.

Aircraft and missiles are, however, currently produced in **relatively small volume,** because changes are frequent. Design is influenced by this problem—which is a fairly common one in Metalworking in general. There are these additional reasons:

Much of the product is made of sheet metal—even the engines in newer planes. Riveting is yielding to welding. Stretch forming, inexpensive dies, avoidance of stress concentrations, weight reduction, new materials, new processes—these are typical of current development.

Money and urgency both hasten research. More research and development money is poured into this field than any other. Materials, techniques, and design are all in the most advanced stages, and developments are almost immediately applied.

New materials are stressed. All of the latest alloys are required: to cut weight, to resist heat, to increase strength, to reduce size. More experience is gained faster as a result. Examples: titanium, high stainless, ceramic coatings.

Weight, size and surface projections are all minimized. Current designs of many products are emphasizing clean lines, reduced weight, smaller size, so aircraft experience and pioneering can be adapted.

Machine tools are another bellwether. The "master tools of industry", they represent the greatest accuracy, the finest detailing and finish, the utmost versatility, and—more recently—the most advanced automation. Much other mechanical equipment shows machine-tool influence—in tolerances, arrangement, basic design.

New ideas from all three industries—aircraft, automotive, machine tool—appear regularly in these pages. We suggest you check them with care.

L. Hartman

New dip-sprinkled mold produces high-strength castings with fine surface detail. These castings are Stellite 31.

R. A. YOUNGS, *Ceramic Engineer*
J. C. HEYMANN, *Metallurgical Engineer*
Corning Glass Works, Corning, N. Y.

This ceramic shell, new development in an age-old technique, produces the fine grain that improves strength and ductility of cast parts, reduces hand finishing, increases productivity.

A shell built up from a special type of glass powder is the key to a new mold process for precision casting of metal parts. Because it is relatively thin-walled, the ceramic mold has a high rate of heat transfer. This allows metal to cool rapidly and results in the fine grain that gives reproducible ductility and high strength to cast parts.

Such structure cannot be obtained easily or consistently by investment casting for two reasons: molds are massive and must be preheated before pouring; metal must be hotter when poured. High metal temperature and slow heat-loss stretch freezing time and large grains form. Some special techniques tend to reduce grain size but are expensive and not always reliable.

The glass-powder method retains the dimensional precision of investment casting. Its starting point is a uniform, pulverized and screened material, Glascast, with the properties given in Table I.

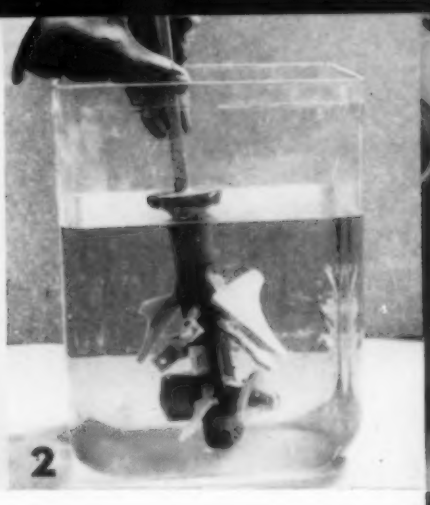
The material, ground to go through a 325-mesh screen, is mixed with water and binding agents. This forms a slurry into which wax prototypes are dipped as in the dip-coating step of investment casting. While the first coating is still wet, Glascast material of larger grain size is sprinkled, and dried for a short time. Then the dipping-sprinkling-drying process is repeated until a shell of desired thickness is formed around the wax part.

After final drying, the mold is heated to a temperature between 1750 and 1920 F. This melts the wax and sinters the mold. After sintering for 15 to 20 min, the shell can be poured immediately, or cooled and stored for an indefinite period. For alloys poured at 1500 F or above, the shell is preheated to permit the lower pouring temperature that forms fine grain.

WIDE RANGE OF ALLOYS

In addition to taking all alloys that can be cast in investment molds, powdered-glass shells are also successful with alloys sensitive to impurities in investment-mold materials. Close control of the glass-powder composition prevents contamination of the molten metal.

As a general rule, shell temperature should be about 1000 F below that of the molten metal. There is no



These Six Steps Make Glascast Shell . . .

for Stronger Castings

thermal shock or mold reaction with metals poured at temperatures as high as 2930 F.

Aluminum alloy and other low-melting alloys can be poured without preheating the dry mold except when preheat is needed to keep the metal fluid long enough to fill small mold cavities or to remove shell moisture absorbed during storage.

Bronzes generally fill cavities better if the shell is heated to about 600 F. For alloys poured at 2600 F or higher, molds should be preheated to 1500 F or above.

Among other alloys cast successfully are AISI 304, 310, 410, and 1017; AMS 5382 and a number of other Stellites; nickel-base alloys containing sizable amounts of aluminum and titanium; Hastelloy "B" and Crucible Steel's Rexalloy 33; and a number of cast irons.

Reaction of mold glass with poured metal is about the same as that caused by conventional investment casting, but is minimized by the more favorable time-temperature conditions.

Aluminum and titanium components of many new alloys tend to combine with oxygen when the alloys

To make a shell by this method . . .

1. **Wax prototypes** are mounted on feed sprue to form a "cluster."
2. **Cluster** is cooled and washed,
3. **Dipped** into powdered-glass suspension,
4. **Sprinkled** with coarser glass, and dried,
5. **Again** dipped and dusted until shell is desired thickness.
6. **Sintering** melts out wax; mold can now be poured.

Thin cores . . .
for hollow shapes require less support than for investment castings. This vane of Stellite 31 is 4½ in. high.

PROPERTIES OF GLASCAST POWDER

Composition, approximate	SiO_2	96.0%
	B_2O_3	2.5%
	Remainder	1.5%
Expansion coefficient, per °F, 0 to 578 F		4.7×10^{-6}
Thermal conductivity, 1800 F, Btu/hr/sq ft/°F/in		16
Specific gravity, approximate		2.18
Softening point, approximate		2730 F

are in the molten state. To prevent this, melting and casting are carried out in a vacuum. Glass molds, being thinner than conventional investment molds, can be degassed quickly and completely.

IMPROVED CASTING SURFACE

Uniform composition and low thermal expansion give the shell good physical stability, and this improves the surface of parts produced by the process.

Spalling and cracking of the mold, which would result in surface defects on the castings, is virtually eliminated. This cuts the cost of parts because of a low rejection rate and elimination of special grinding and finishing operations. Finish after vaporblasting is in the order of 40 microinches; often no additional finishing is required.

Absence of mold impurities has advantages too: It reduces reaction with molten metal; eliminates entrapment of gas bubbles at or near surfaces of castings; and prevents gas from being entrapped in body of the castings.

WHY GRAIN SIZE IS SMALL

Amount of metal superheat, and cooling rate are the major factors affecting grain size. In freezing, the metal passes through a mushy stage, which induces grain growth. Rapid heat transfer through the thin mold walls produces small grain by shortening the mushy-stage time.

Intricate casting shapes and thin sections may need vacuum, pressure, or centrifugal force to help relatively cold metal fill the mold cavity. High mold strength and stability facilitates these aids.

SOME LIMITATIONS

But the process is not a substitute for good foundry practice. Good gating and risering is needed, as with other types of molds, to feed metal properly to the mold cavity. Clean melting, molding and pouring off are required to prevent oxides and other impurities going into the casting.

Mold strength can be controlled within certain limits. Dropping sintering temperatures from 1920 F to about 1700 F reduces mold strength. Although this means that more careful handling is required, the mold collapses more easily and restrained-type castings can be made in such molds without suffering hot tear on cooling.

While shrinkage must be allowed for both the wax prototype and the metal being cast, powdered-glass molds give higher dimensional accuracy than investment casting: not less than 95% of parts cast in powder glass are within 0.003 in./in. of nominal size; 99.7% are within 0.005 in./in.

SIZES AND SHAPES

Parts can be as large as those produced by most investment techniques. In larger sizes the lighter weight of ceramic glass molds makes them easier to handle.

Thin sections and fine detail are readily obtained. For example, gas turbine blades of AMS 5382 alloy, 1¼ in. long, 1 in. wide and ⅛ in. maximum thickness, measured 0.015 in. at the trailing edge. Wall sections can, of course, be made smaller with assistance from pressure, vacuum or centrifugal force.

Casting characteristics of a metal are important in

Machining is reduced . . .
or eliminated by reliable reproduction of detail. Surface finish after vapor blasting is 40 microinches for these parts, shown here a little larger than actual size.

establishing fillets and corners. A radius of 0.010 in. can be produced satisfactorily. Fine lettering (raised or depressed), and lines inscribed 0.001 to 0.002 in. deep can be reproduced. Fineness of detail is limited by the 40-micron size of the glass powder in the dipping slurry.

Sintered strength of molds permits one-end support of cores that, in a conventional investment, might collapse when hit by molten metal. Long cores thinly supported at one end may break in a powdered-glass mold too, but they can be somewhat thinner or longer than in other precision casting techniques. Of course, core strength cannot be higher than that of other mold sections. Low-temperature curing will weaken both.

COST CONSIDERATIONS

Present practice requires 6 hr for building the shells, followed by a minimum of 8 hr drying before firing. Control of room temperature and humidity, and special drying rooms can cut this time in half.

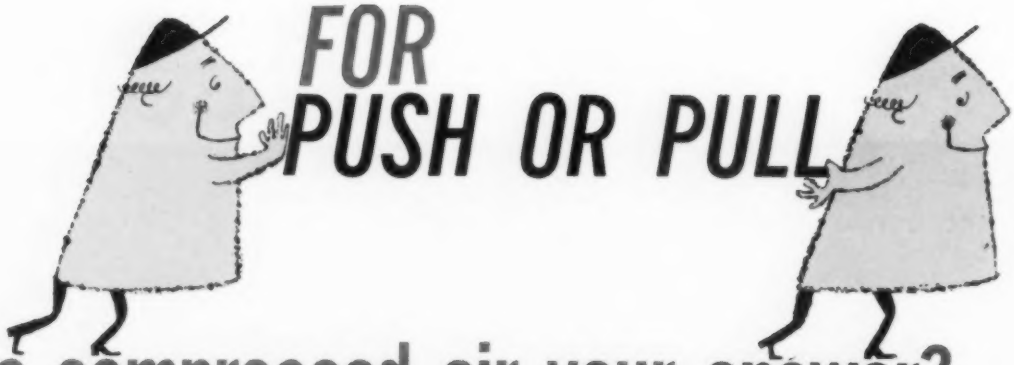
Shell formation is only a series of dipping and sprinkling operations, so the process is much more economical than investment casting with its additional canning, investing, drying and handling steps.

Mold-material costs are low because of the small quantities required. Retaining the sintered glass for re-use can further cut costs. Fully automatic production is possible because operations are mechanical and involve little skill.

EDITOR'S NOTE: Known in China 3000 years ago, the art of "lost wax" casting seems to have been reinvented during the Italian Renaissance and was practiced by the famous gold- and silversmith, Benvenuto Cellini. In the early part of this century it was used almost exclusively by dental workers. Industry's demand for parts made of alloys progressively more difficult to machine has turned investment casting into an industrial process.

"Design for Investment Casting," Apr '56, p 166, gives advantages and limitations of the method, lists casting alloys available, suggests tolerances and other design data. A variation of investment casting uses patterns made of frozen mercury: "Frozen Mercury Process," Mid-Oct '55, p D13.

Other pertinent articles: "Evaluation of Casting Processes," Mar '54, p 139; "Investment Castings: "They're Getting Bigger," Apr '53, p 137.



FOR PUSH OR PULL ...is compressed air your answer?

HARRY L. STEWART, J. M. MORITZ — *Logansport Machine Co., Inc.*

Air power doesn't mean just airplanes. It also embraces the rewarding field of pneumatics. This article, a comprehensive guide to advantages and limitations, tells what you will want to know about considerations like:

- **Relative Costs**
- **Direct vs Remote Control**
- **Sequential Circuits**
- **Cushioning Devices**

A problem often faced in designing automatic equipment is the choice between hydraulic, electric and pneumatic power elements. The air-power type of "work horse" has been receiving increased attention, particularly as a rival to hydraulics.

Pneumatic equipment offers many advantages but there are drawbacks to be weighed. There is also a choice among methods of putting air power to work. Specific needs will dictate the selection. Here is a detailed run-down on the elements involved:

GENERAL ADVANTAGES

• **Availability.** Most plants have compressed air handy. Operating pressures range from 80 psi to 120 psi, with 80 to 90 psi a reliable assumption for design needs. Adding an auxiliary air tank will increase capabilities; the tank satisfies intermittent heavy demands on the system and is then slowly recharged by the compressor.

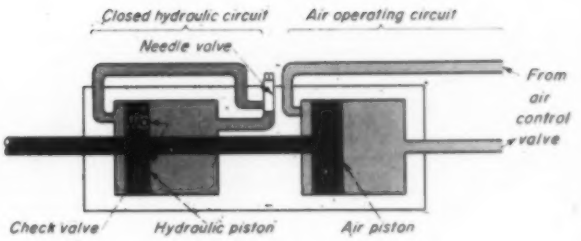
• **Speedy Cycling.** Four-way air-control valves built now are capable of up to 600 reversals per minute in industrial applications; and air-powered pistons can give repeated hammer-like blows when exhaust ports and valves are designed for the application.

• **Less Expensive Components.** A four-way pneumatic pilot valve will cost $8 to $10; a four-way hydraulic pilot valve can cost $35. A four-way pneumatic master valve costing $17 contrasts with one for hydraulic operation at approximately $36. Pneumatic cylinders of a given bore size are considerably cheaper than hydraulic cylinders although air-cylinder working pressure is usually lower. Additional savings come from including only a portion of the cost of the power source (compressor).

For applications with limited life expectancy and light loads, such as a wood or plastic clamp, air components are inexpensive. Cylinders may be die-cast or made of stamped steel parts; valves may be lightweight and inexpensive. A bonus is the relative saving in piping cost. Pneumatic piping is inexpensive, and the return pipes needed in hydraulics can be omitted because exhaust air goes into the atmosphere. On large jobs, such savings can be considerable.

• **Clean Medium.** Compressed air, properly filtered, is clean. Leaks are neither unsightly nor dangerous. Reason for the stipulation "filtered" is that pipe scale, lime, rust and condensation will gather in piping and cause damage if not removed before entering each pneumatic layout. When clean, air exhausted from cylinders and valves can be used to clean work pieces or work areas.

• **Safety.** Pneumatic components are acceptable around furnaces, smelters, and other "hot spots." High temperature packings, suitable for working conditions up to 500 F, are now available for cylinders and valves; but sufficient lubrication must be provided for satisfactory seal life. Silicone and other high-temperature greases work excellently. Pneumatic equipment is especially



1 Dual fluid circuits . . .
one pneumatic and the other hydraulic, can be linked to control piston motion. Air power is the motivating means; oil flow is metered through a needle valve for speed control.

applicable in explosive atmospheres because complex circuits can be designed without electrical elements.

• **Teamwork.** When coupled with a closed hydraulic system, Fig. 1, pneumatics offers the advantages of compressed air's fast action combined with the even feed made possible by hydraulics.

SOME LIMITATIONS

• **P-V Fluctuation.** Plants continually add equipment to pneumatic circuits without regard to air-compressor capacity. Fluctuation in pressure and volume usually occurs at the beginning of a work shift or after the lunch period when all equipment goes into operation simultaneously. Pressure can drop so greatly that clamping devices do not hold. Power loss can be enough to make a cylinder inoperative. Systems become sluggish. Pilot valves may not function properly. Sequence valves may fail to operate, or operate at the wrong time. Flow-controlled feeds become erratic.

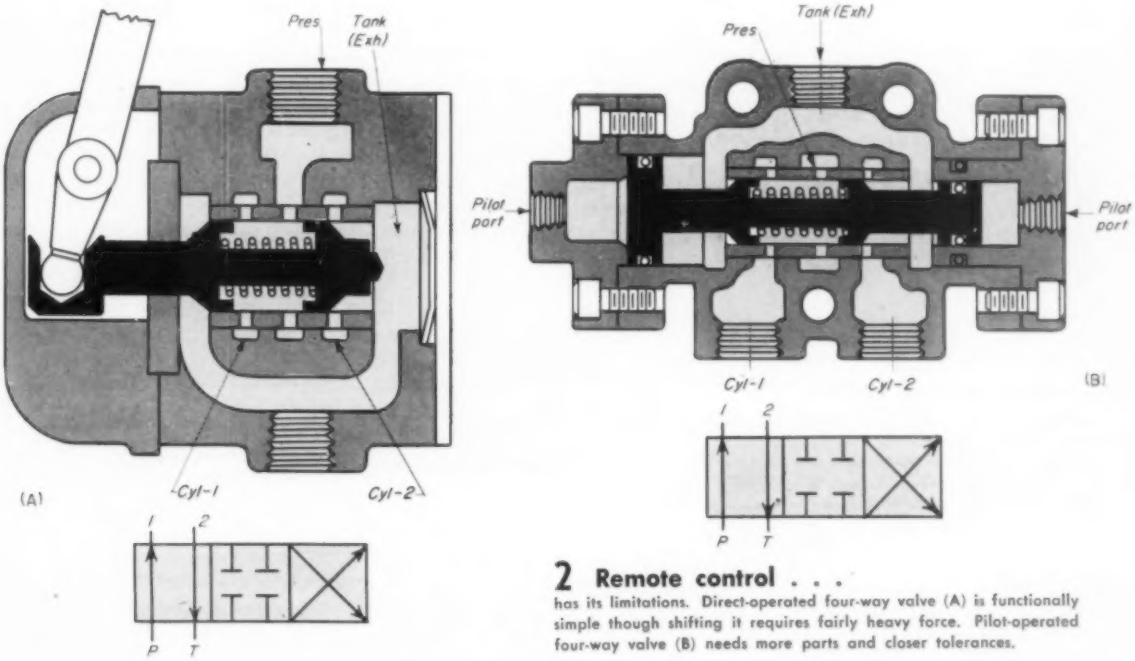
• **Air Expense.** Components are relatively cheap, but the medium is not. Compressor efficiency is relatively low. There is considerable power loss as air passes through the system, and air leaks may not be noticed.

• **Moisture Problems.** It is practically impossible to keep moisture out of air lines. Cooling caused when an air line passes from a heated room into outdoor equipment in winter weather may freeze (or turn to slush) moisture in the air line—clogging piping, filters, valves and cylinders. Heating equipment can be installed but that would be expensive, especially on large outdoor installations. In this situation, hydraulics can more economically meet requirements.

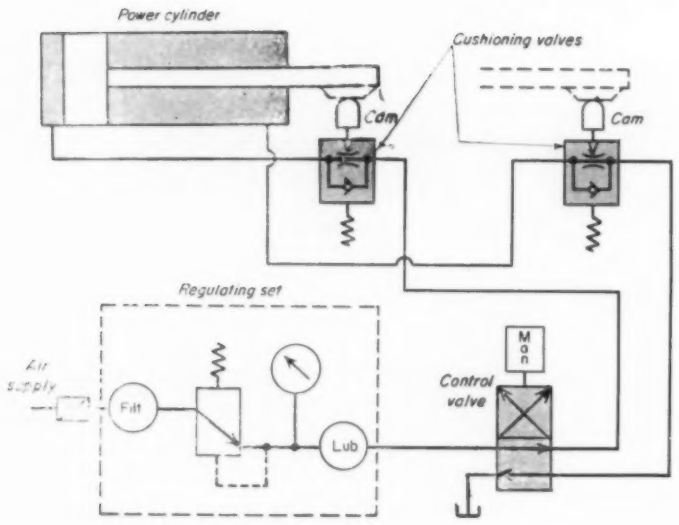
• **Lubrication Needs.** Lubricating and filtering equipment is particularly important for proper air-circuit design. To cut his costs, the installer often omits these auxiliaries. The customer puts his machine into operation and soon experiences a failure. An added $30 to $50 for lubricators and filters is good insurance for system protection, and automatic lubrication adds greatly to efficiency.

• **Severe-duty Extras.** Cylinders for severe-duty needs usually must have heavy steel covers, precision-honed steel cylinder tubes with welded tube rings, ground and polished piston rods, cup packing on the piston, and built-in cushioning devices. Operating valves should be equivalent to cylinders in ruggedness and have ample porting to pass inlet and outlet air.

Pneumatics loses economy when applied to extremely



2 Remote control . . .
has its limitations. Direct-operated four-way valve (A) is functionally simple though shifting it requires fairly heavy force. Pilot-operated four-way valve (B) needs more parts and closer tolerances.



3 Individual flow-control . . . valves are cam-operated in this circuit to control exhaust-orifice area. Separate settings govern length of cushioned stroke and its location within full piston travel. This is an example of external cushioning.

heavy loads. A 50-ton load moving vertically would require a special-bore 38-in. air cylinder operated at 90 psi. Valving would also be expensive. For this application, a complete hydraulic system could be purchased for less than cost of the air cylinder, and the hydraulic system would be cheaper to operate. Maximum size of installation should be limited to standard-bore cylinders which, for non-rotating applications, usually don't exceed 16-in. dia. and for rotating cylinders, 20-in. dia.

• **Time Lag.** Although compressed air expands rapidly, which moves valve and cylinder pistons at high speed, the time lag in large systems must be compensated for in the time cycle of the machine. This problem doesn't usually arise in applications with small-bore, short-stroke cylinders. But where long-stroke, large-bore cylinders are needed and the line from control valve to cylinder is 10 or 15 feet long, a time lag of five to seven seconds can occur between valve shift and piston start. If a flow control valve or other restriction is placed in the exhaust side, even higher time lags must be expected.

DIRECT CONTROL vs REMOTE CONTROL

Direct (master) controls are operated at the valve whether by a person, a cam, or a solenoid. Remote ("pilot-operated") controls are at a distance, operating small pilot controls which in turn, move pilot pistons of larger directional-control valves.

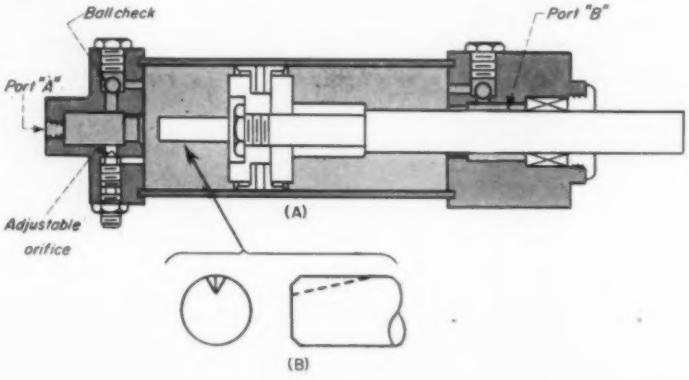
Direct controls are usually more rugged in design and less complicated. Fig. 2 (A) shows cross-section of a direct-operated four-way control valve for manual operation, and Fig. 2 (B) is cross-section of a pilot-operated control valve. Time lag is reduced with direct control but more physical effort is usually required.

In large installations, remote control is advantageous because the directional-control valve can be placed near the operating cylinder, and the pilot valves at a distance. This substitutes small pilot piping for long runs of large direct piping. The operator can be at a safe distance from dangerous or disagreeable hot spots, explosive locations and dust-laden atmospheres.

PISTON FORCE AND SPEED

Theoretically, it isn't difficult to calculate force and speed of a piston; practically, it's impossible. Rod-packing friction is dependent on rod-packing tension, type of packing, and finish and diameter of piston rod. Properly installed rod packing will cause very little friction, but replacement packings seldom get the same careful treatment.

Finish on piston rod and cylinder tube will influence



4 Adjustable air cushion . . . internal-cushioning method has needle valve to control speed. High-inertia, low-friction loads need longer cushion strokes for adequate deceleration control. Air-releasing passage is adjustable orifice in (A), for which nonadjustable tapered slot in (B) can be substituted.

friction load and packing life. For best results, rod finish should be better than 35 micro-inches, on the tube, better than 20 micro-inches. These goals are fairly standard. The smoother the surfaces, the longer the packing life.

Packing type and fit also influence friction. Typical packings include cups, O-rings, quad-rings, blocked V and Chevron. Any packing must be properly lubricated to reduce friction and increase packing life. Sum of all causes that create friction should not exceed 10% of theoretical force of a small piston and 3 to 4% of a large one.

Theoretical force exerted by a piston in either direction is pressure multiplied by net area. For a single-acting piston with spring return, subtract the spring force calculated or measured at the piston position under study. To illustrate, force exerted by the piston on the return stroke of a 4½-in. piston with 1-in. rod, operating at 100 psi is:

$$F = 100\ (15.90 - 0.79) = 1511\ \text{lb}$$

Friction losses will reduce this figure by 3 to 10%. If the application required a 1500-lb force, choose the next larger cylinder size for reliability.

Time of piston travel can be estimated by dividing the volume swept (piston area times stroke) by air flow to the cylinder. This does not account for time lag caused by shifting of valve pistons, or air moving through lines. It also does not allow for the break-away period before the piston moves.

CUSHIONING DEVICES

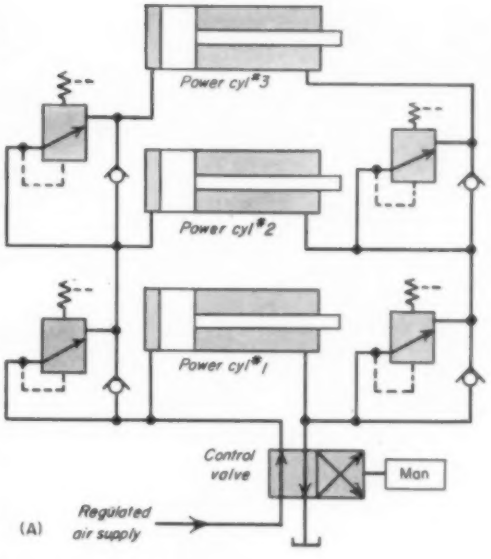
Because the piston usually travels at high speed, it is best to reduce its impact against the cylinder covers as much as possible.

External cushioning can be accomplished with a cam-operated cushioning valve (Fig. 3), a hydraulic check or snubber, or an external stop made of resilient material. These, requiring much space and external attachments (such as a cam) on a moving member, are not always feasible.

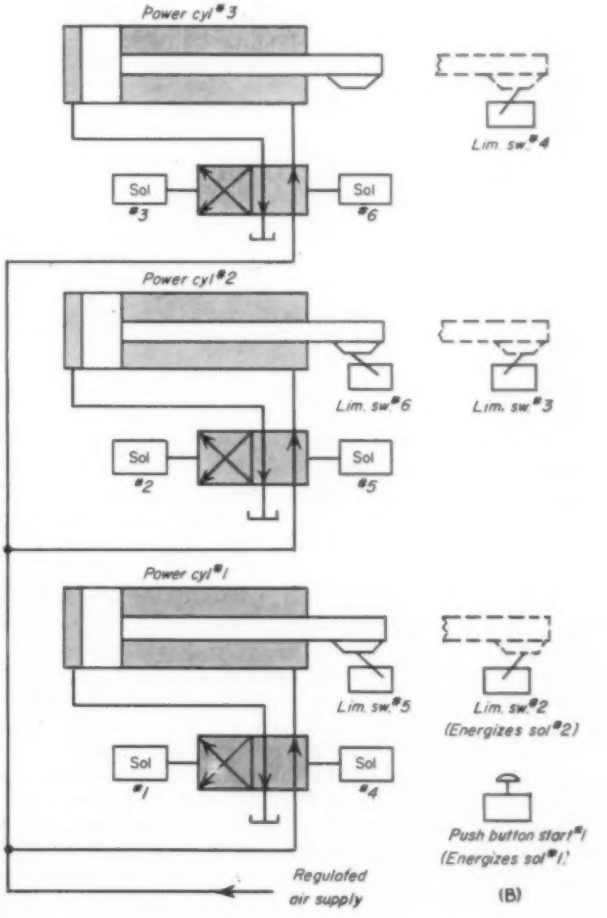
Internal cushioning (Fig. 4) is usually more adaptable. Stopping is cushioned at either end of piston travel because air trapped ahead of the piston must escape to port through a designed restriction. Two examples are: through the adjustable orifice shown in (A); or, for simpler design (B), through the clearance between cushion nose and bushing at the rod end.

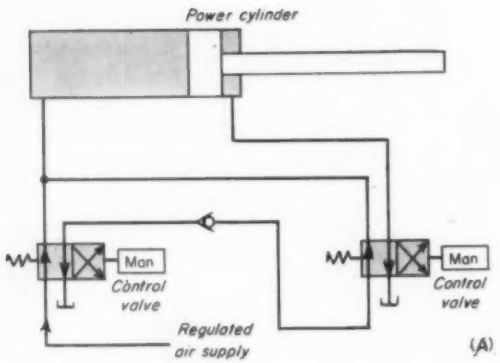
A ball check allows quick air entry to the cylinder working surface on the return stroke so full force is immediately available. Other designs have collapsible seals in the cushion. They collapse when air pressure is applied to reverse the piston, allowing air to flow quickly to the working surface.

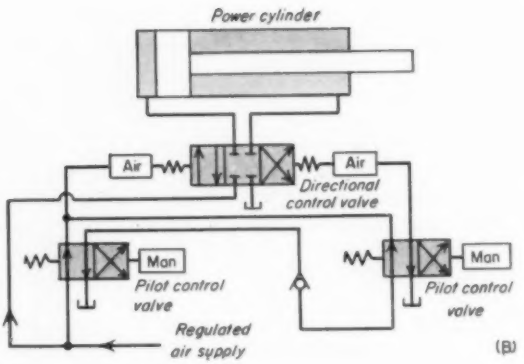
A cushioning device is not a flow controller, but acts only as a snubber. The ideal cushion decelerates a piston from maximum speed to zero in a very short distance. Length of standard cushioning noses or collars is approximately 1 in. In high-speed applications where loads are on freely moving rollers or on roller-bearing slides, longer cushions are necessary, often as long as 6 to 8 in. Long internal cushions at the cylinder blind end can be accommodated but at the rod or cap end they become rather complicated. Usually a



5 Choice of two ways . . .
to control multiple operation is seen here. With sequence valves (A), built-up line pressure triggers each cylinder in rotation; with master valves (B), sequencing is by solenoid valves and limit switches at end of each cylinder stroke.







6 Safety circuit . . .
requires manual actuation of both two-way valves for each direction of cylinder motion. In (A), circuit is direct-operated; in (B) same function is performed by pilot actuation.

cushion nose is straight except for the radius on the end for guidance.

Tapered cushion noses are rarely used to control deceleration in air cylinders because clearances would approach normal manufacturing tolerances. In some instances, a tapered slot can be used on long cushions, especially with large-diameter cylinders trapping a large volume of air, as in Fig. 4 (B).

Internal cushioning has little or no value if the piston does not travel to the end of its stroke. On very-short-stroke cylinders (under 1 in.) cushioning devices are not recommended because their noses would be in the orifices at all times. It would be less expensive to use flow-control valves.

SEQUENTIAL OPERATION

Multiple operations can be controlled two ways: by the use of sequence valves; or with enough master valves to operate each cylinder in sequence.

Sequence valves, Fig. 5 (A), are essentially piloted relief valves in series—the first valve set to open at the lowest pressure, and the rest successively higher.

When correctly set, each cylinder operates properly before the pressure is high enough to trigger the next sequence.

However, reliability suffers if air pressures fluctuate for any reason and destroy timing. For example, if the pressure drops near or below the opening pressure of a sequence valve, the valve will be erratic and fail to open. As a result of this failure the next stop or sequence will not occur.

A jam in the operating cycle (when a piston meets resistance) will trigger a sequence valve and start the next sequence prematurely. Some operations require pressure at the first step to be higher than at the second, and it isn't always practical to redesign cylinders just to use sequence valves.

Master control valves will serve more dependably. In Fig. 5 (B), push-button #1 energizes solenoid #1, and each succeeding step is controlled by limit switches. Increased reliability comes from the fact that no cylinder can move until the preceding one has operated its limit switch.

FOOL-PROOF OPERATION

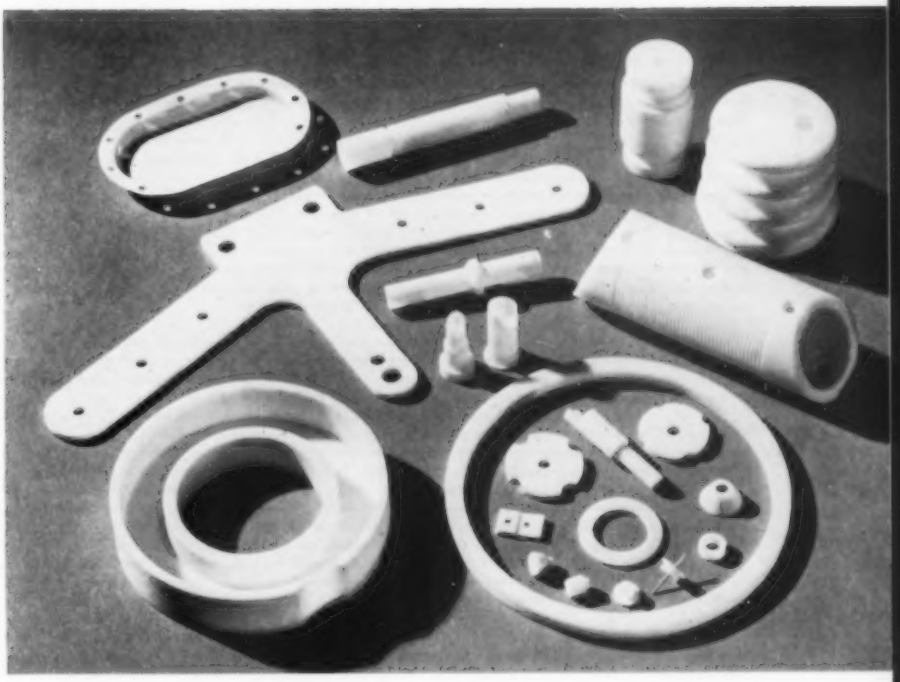
Safety circuits can be designed for direct or remote control, Figs. 6 (A) and (B). Both manual-control valves must be operated together to move the piston. An operator cannot tie down either control valve and get a repeat cycle. Circuits are safe as long as the operator follows regular procedure, but if he can circumvent part of the control cycle, safety factors are destroyed. Air pistons move quickly, so safety precautions must be incorporated in most pneumatic circuits.

EDITOR'S NOTE: Details in the construction, operation, and application of two-way, three-way, four-way, and other solenoid-operated valves for pneumatic and hydraulic service are discussed in "Solenoid Valves for Fluid Directional Control", July '55, p. 162. Formulas and curves for determining valve operating time, and detailed treatment of many of the factors contributing to speed of response are presented in "Calculating Time Lag of Hydraulic and Pneumatic Valves", June '56, p. 158.

Why Hate High-pressure Pneumatics?

To some, high-pressure pneumatics is dangerous, complicated and heavy; but these conclusions are not always justified, according to H. E. Wright, Convair Div. In a paper for the SAE National Aeronautics Meeting in Los Angeles, Sept. 30, 1957, he makes the point that the danger of escaping air blasts is not much greater at 1500 psi (100:1) than at 30 psi (2:1) because sonic velocity is the result in either instance. Complication is reduced in modern systems because external oil snubbers can be replaced with plastic snubbers in conventional cylinders.

Weight of pneumatic systems is also competitive with hydraulic systems. For example, a 20-hp, 1500-psi pneumatic system weighs less than a 3000-psi equivalent hydraulic system at over 40-ft transmission distance. Weight and power requirements for each component of air and hydraulic systems are compared under various conditions. High-pressure air is faster, lighter, able to operate at higher temperatures and can better withstand nuclear radiation; it is a safe and practical motive fluid.



how to design cost out of PLASTIC PARTS

RONALD L. DAGGETT

Professor of Mechanical Engineering University of Wisconsin

Here's a run-down on costly requirements, such as heavy wall sections and extra-close tolerances, that aren't always necessary. Charts classify materials and processes for ready reference.

Transforming raw plastics into finished parts is now routine. But doing it at lowest cost requires judgment —and self-control—because more design features are often specified than are really necessary.

Three elements strongly influence cost of the part: the material, the production process, the design features. These comprise a simple chain reaction. Selecting the most economical process depends on choice of material which, in turn, is limited by requirements set for the part. As these requirements are simplified—consistent with functional demands—more processes become applicable.

Perhaps you can eliminate, or at least reduce need for, design features like these:

• **Heavy wall sections.** They boost part weight, lengthen processing cycles; often result in warping, high shrinkage, excessive rejects. Few plastics and processes are recommended for sections greater than $\frac{1}{4}$ or $\frac{3}{8}$ in.

• **Unusually close tolerances.** They increase molder's problems of control, cycling, tooling; lead to closer inspection—and high rejection rates. Use commercial tolerances whenever they will meet the need.

• **Unequal cross-sections.** They result in warpage, sink marks, poor flow of plastic in the die, unbalanced cure, residual stresses. Instead of radical section changes like notches and sharp corners, simplify with smooth contours, rounded corners, uniform wall sections.

• **Hand finishing.** This and other "secondary" operations increase labor on molded parts. Proper mold design can cut hand finishing to a minimum.

• **Inserts.** They drastically increase press-cycle time, add to number of operations for molding and finishing.

• **Undercuts or re-entry designs.** They complicate tooling, require special cores, multipart dies, slower press cycles. In extreme cases they result in a part assembled from two or more molded pieces.

• **Light or transparent materials.** They are easily contaminated, especially in compression moldings; reduce possibility of using scrap; exaggerate mold faults. Contamination from switched colors becomes a serious drawback of injection molding on short runs.

• **Scattering.** Concentrate "features" in one plastic part

TABLE I—PRODUCTION PROCESSES FOR PLASTIC PARTS

Basic Processes	Primary Characteristics	Principal Materials
Compression molding	Mold opens to receive material, closes directly on material, runs hot to cure parts. May be hand, semi- or full automatic molding. Cure time and press cycle control press time.	Thermosets: Granules and preformed mat. Reinforced matched-die moldings.
Transfer molding	Materials preheated in separate chamber, transferred into preclamped hot mold. High pressures required with parts cured in dies.	Thermosets: Granules or preformed mat.
Injection molding	Materials plasticized in tunnel, injected hot into preclamped "cold dies," parts cooled in dies.	Most thermoplastics.
Extrusion molding	Hot materials screw-plasticized and extruded through shaped die at uniform rate to develop sheet, rod, tube or special cross section in continuous lengths. Takeoff device helps size and chill.	Most thermoplastics. Some thermoset extrusions available also.
Vacuum forming	Sheet stock preclamped in frame, heated to forming temperature, and drawn over male or female mold and vacuum-formed to mold contours.	Sheet thermoplastics: from thin film to heavy-walled commercial moldings up to 3 x 5 ft. and 18 in. deep.
Casting	Liquid resins poured into prepared dies and under controlled conditions involving heat and/or catalysts for thermosets.	Thermoplastic: acrylics, vinyl plastisols, thermosets; phenolics, epoxies, polyesters, allyl resins, urethanes.
Laminating (low-pressure or matched-die molding)	Multiple layers of reinforcing materials with incorporated resins, are under heat and pressure, using catalysts. Used for high-strength parts with large areas.	Continuous, random or woven reinforcements with thermosetting resins: phenolics, polyesters, epoxies.
Blow molding	Partially preformed or preshaped hot thermoplastic stock is blown into dies and chilled. Used for hollow articles.	Most common thermoplastics.
Expansion molding	Dry resins containing blowing agents are heated with live steam blown into porous mold. Alternate is liquid resins foamed using heated mold-form.	Beads in polystyrene, liquid resins in several thermoplastics and thermosets.

to eliminate need for other parts, successive operations, intricate assembly. And apply imagination to capitalize on such inherent plastic properties as finish and color, light weight, corrosion resistance, lower cost, texture.

MATERIALS AND PROCESSES

Typical processes and their commonly applicable materials are listed in Table I. Nine processes account for almost all molding of forms or shapes. Each process has certain characteristics adapting it to selected material groups, as shown.

Thermosets usually come in granular form, as sheet laminants or as liquid or solvent dispersions. In presence of catalysts they harden as a function of heat, pressure and time, so thermosetting materials lend themselves to hot-die curing techniques. Catalysts reduce temperature but usually extend curing time.

Thermoplastics are materials softened by heat, so exceed thermosets in wide range of process possibilities. For example, they can be heated dielectrically or dispersed in plasticizers or in solvents. These characteristics underlie most processes applicable to thermoplastics. The processes commonly utilize either heating, forming and chilling; or casting or coating with these materials from liquid form.

Table II lists eight basic types of parts currently made from plastics. Each, excepting extruded products which are unique, has two or more applicable processes listed in order of preference.

Table II—Characteristics of Plastic Parts

If the part requires these CHARACTERISTICS
Large area of intricate shape, with thin walls and shallow draw; occasional cutouts and good surface finish
Large, semi-rigid, deep draw with thin walls; rigidity provided by ribbing or close wall-thickness control; part usually symmetrical
Large area, rigid, shallow draw with good impact resistance
Hollow with neck, thin walls, semi-rigid to flexible; outer surface finish good, high production; color secondary
Medium-size, rigid, high finish, with good dimensional stability for assembly to metal parts; color secondary
Small, complex shape with good strength; low cost and wide colors
Flexible to rigid, long lengths with complex shapes and widely variable wall thicknesses
Tough, rigid, heat-resistant with wide color choice and simple shapes

Advantages	Disadvantages	Remarks
Single-cavity short runs and intricate parts possible. Permits wide range of materials and fully automatic molding. Good finish.	Flash lines common. Some materials have color limitations.	Max weight molding 35 lb to date; very small parts possible. Limits on walls: max ½ in., min 0.025 in. Thick sections should be avoided.
High production rate per cavity. Excellent dimensional control and slightly superior molded properties.	May require special press. Premium materials needed.	Excellent where delicate inserts are needed; complex parts possible.
High production rates with wide variety of material.	Equipment and tooling costs high. Large production runs required.	Max weight molding 18 lb to date; max size approximately 3 x 5 ft. Practical section thickness range 0.020–0.100 in. Min section 0.012, max 0.250 (avoid if possible.)
Low-cost dies for simple shapes, high continuous-production rates, almost infinite choice of shapes.	Parts with critical dimensions may involve much trial-and-error die sizing.	Wide size range: 0.0005-in. films to heavy sheet, filaments to 6 in. Sheet width up to 54 in.
Simple tooling permits short-run production. Samples easy to produce, simplest basic technique and large parts possible.	Walls tend to thin and be non-uniform. Draw-depth to diameter ratio limited. Generous tolerances required.	Part size limited by machine size: smallest sheet, 10 x 10 in.; largest, 60 x 40 in. Practical sheet thickness range: 0.005–0.150 in.
Hollow objects using plastisols in special molds can be made. Simple basic process with relatively low-cost tooling.	Shrinkage a problem, but can be controlled through fillers and choice of resin. For low production rates.	Casting size and section thickness limited only by shrinkage of resin chosen.
Virtually no size limits with hand lay-up. High strength-to-weight ratios where Fibreglas is filler.	Manual labor high for hand lay-ups, moderate for matched die molding, relatively high material and preparation costs.	Very large parts in heavy section possible.
Hollow articles or re-entry shapes possible.	Highly specialized proprietary processes.	Largest moldings to date are 10 gal acid containers. Larger parts possible.
Simple process using simple molds.	Close process control required for liquid formulations.	Many materials possible; with wide density range: 1.5 to 30 lb/cu ft.

and Applicable Processes

Then specify one of these PROCESSES	Here are some TYPICAL APPLICATIONS
1—Injection molding (large machines) 2—Vacuum forming from sheet stock 3—Extrusion and vacuum forming-in-line from hot material 4—Matched-die or low-pressure reinforced molding	Refrigerator liners, auto door panels, phonograph motor boards, air-conditioner control panels.
1—Injection molding (large machines) 2—Matched-die or low-pressure reinforced molding 3—Casting with plastisols 4—Vacuum forming	Chemical shipping containers, wastebaskets, clothes hangers, dishpans
1—Compression molding 2—Matched-die or low-pressure reinforced molding 3—Injection molding 4—Vacuum forming 5—Post-forming laminates 6—Transfer molding possible	Machine housings, refrigerator cabinet panels, suitcases, cafeteria trays, boat decks, auto body parts
1—Centrifugal casting 2—Blow molding 3—Injection molding in halves, assembled by cementing or welding	Bladder-type accumulators in oil systems, bottles and holloware
1—Compression molding 2—Transfer molding	Heat-resistant handles for appliances washing machine agitators, pump housings
1—Injection molding 2—Extrusion with secondary fabrication	Electrical switches, pump impellers, gears, handles
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Four-way Disaster Vehicle

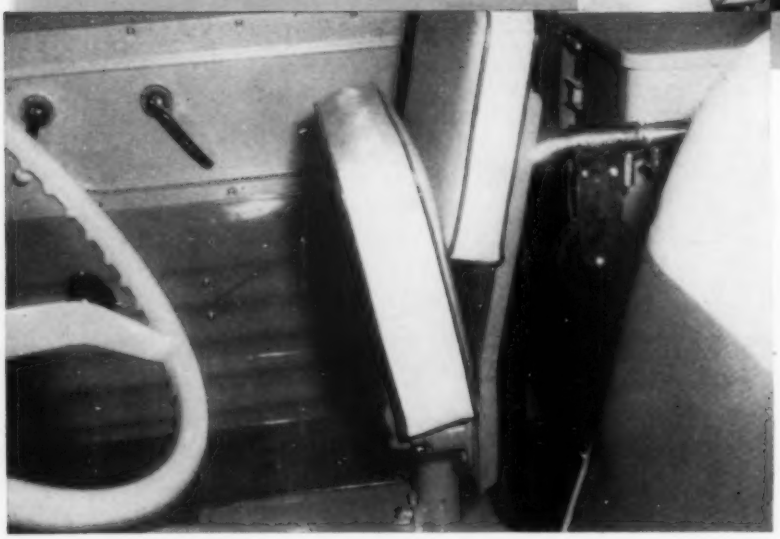
Rear body section is raised above cab roof . . .
to increase headroom for crew when used as a squad cruiser, or for a standing attendant with stretcher patients. Seat cushions and back rests are plastic-covered foam rubber; walls are sheets of white laminated plastic; floor covering is linoleum. This construction simplifies cleaning.
As ambulance, stretcher patients are carried on seat cushions, on a folding cot in the center aisle and in a collapsible stretcher hanging over the left-hand seat cushion. When not in use, cot and collapsible stretcher are stored in auxiliary equipment compartment; remaining stretchers and blankets are stored behind hinged back rests. Doors at front provide access to equipment compartment behind cab. A second door opens this compartment from the outside. Small cabinet at right is a medicine chest. Tanks under seats carry 150 gal of water and compartment in left-hand tank holds low-pressure water hose. Additional hose is carried beneath hatch in floor. High-pressure chemical hose, for fighting oil fires with foam, is in a compartment between rear step and frame.

Fire pump is mounted under chassis . . .
and delivers 200 gpm at 200 psig. External suction and discharge connections are under hinged covers on both sides of car; controls select internal or external suction and adjust discharge pressure. With this arrangement, water in tanks can be used to fight fires while pump is connected to an external source. External suction hose can be carried in compartments beneath frame. Foam-forming chemicals in tank under floor produce 6000 gal of foam when mixed with water.

IN NEW PRODUCTS

Ambulance, squad car, fire fighter and rescue unit are combined in a single vehicle made by the Christopher Co. of New York City, a division of International Auto Industries, for use as a fire-department auxiliary or as a civil defense unit. Built on a one-ton truck chassis, it carries four litter patients or 12 seated men plus water and foam for fighting fires, and auxiliary equipment for rescue work. Features built into this vehicle contributed to complexity of styling problem. Car had to be extremely functional but still have good lines. Riding qualities were improved by reducing thickness of spring leaves and adding a rear swaybar.

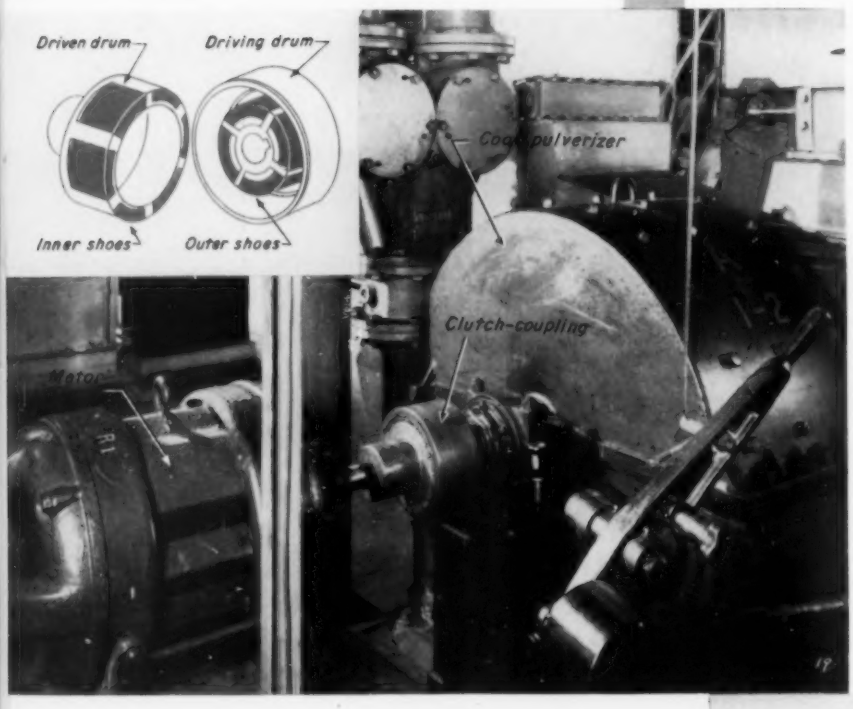
Auxiliary equipment stored in cab . . .
includes hose nozzles, resuscitator, two portable 500-w floodlights, a portable 1500-w engine-driven generator, a portable engine-driven pump, an oxy-acetylene cutting torch and extra dry chemicals for fire fighting. Optional equipment includes a front or rear winch. Features incorporated in this vehicle were first discussed with hospitals, fire departments and civil defense and industrial safety groups.



Attendant's seat folds upward . . .
to reveal compartment in floor which stores additional lengths of low-pressure water hose. Seat and support can be removed entirely for easy access to accessory equipment stored in rear of cab. Also, this area is accessible from the passenger section and from the outside. Cab contains controls for power take-off to pump, pressure and vacuum gages for pump and a dash-operated remotely controlled spotlight.

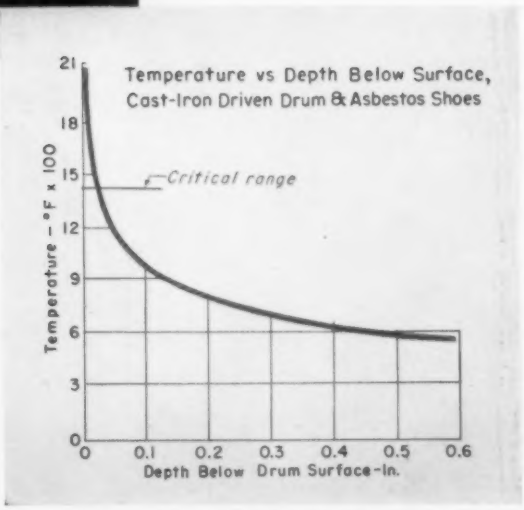
Metal Shoes Prolong Clutch Life

Heat-checking cracks, appearing in the driven friction surface of a centrifugal clutch, wore away the driving shoes and limited service life to about 100 starts of a high-inertia load. Substituting metal drive shoes for shoes made of heat-insulating material, the O. S. Walker Co., Worcester, Mass., stopped the formation of heat checks and extended indefinitely the time between overhauls.



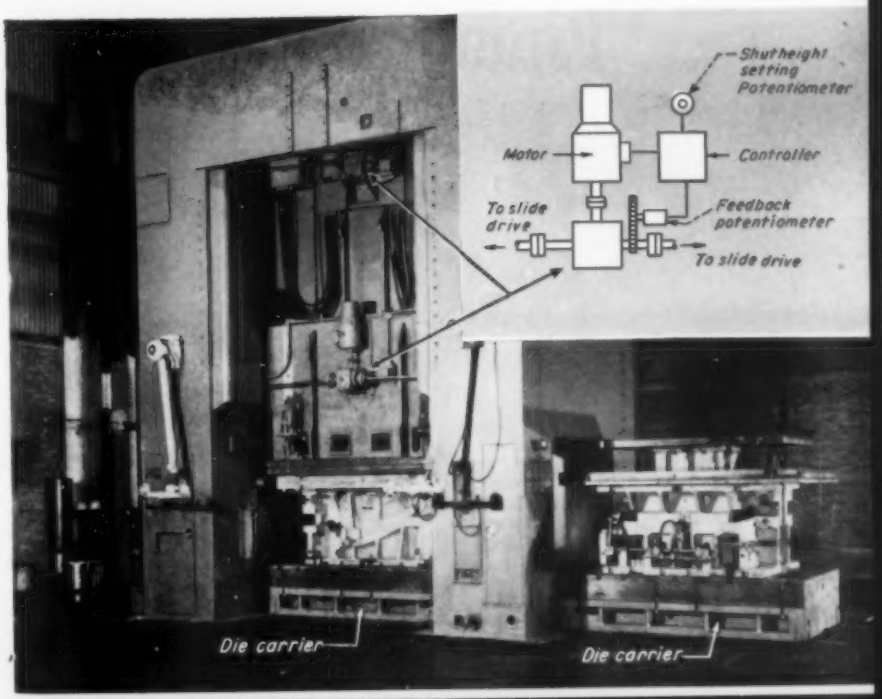
Clutch is an assembly of two telescoping cast-iron drums, . . .
each having a set of friction shoes carried in radial slots. Outer shoes, on driving drum, are designed to transmit motor torque at rated hp and rpm. These shoes start the load and accelerate it to rated speed. As load reaches rated speed, shoes on driven drum are engaged to obtain an overload torque capacity of 200% of motor rating. Clutch is called the Rawson Coupling (named for its inventor) because it functions as a coupling after the load reaches operating speed. With this device, high-inertia loads are started by normal-starting-torque induction motors (Nema Design B) of horsepower rating required to drive load at operating speed. Photo shows application to Riley Stoker Corp. coal pulverizer.

Riley's experience with these couplings . . .
led the company to engage the Battelle Memorial Institute to improve the coupling's resistance to heat checking. Battelle's work indicated surface temperature cycling though the iron's critical range was primary source of strain that produced the cracks. By changing composition and annealing drums to obtain a ferritic structure, Battelle increased to 200 the number of starts before failure. Later, O. S. Walker engineers tried a new approach. They developed a copper-alloy shoe to conduct heat away from the surface faster than it dispersed through the drum. This reduced the temperature gradient beneath the surface and stopped the formation of heat checks.

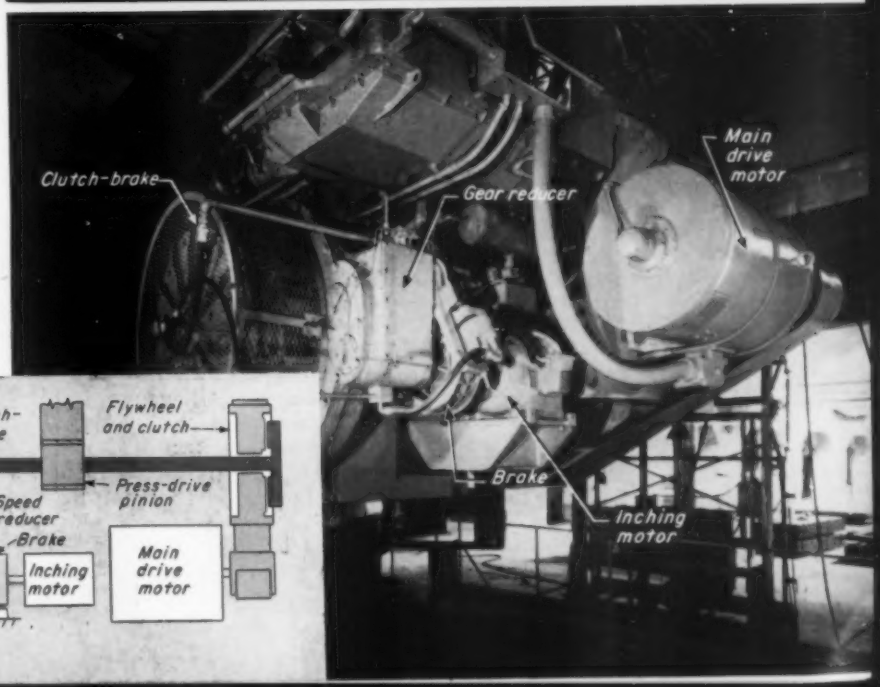


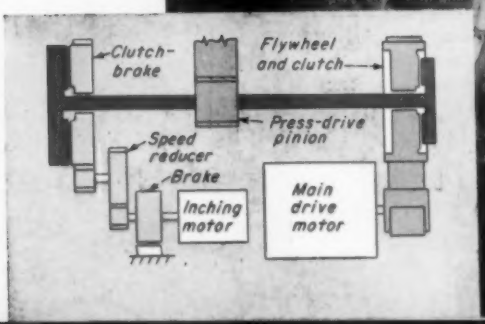
Press Built for Fast Die Change

In a 600-ton press equipped with two bolster plates mounted on power-driven carriers, Danly Machine Specialties, Inc., Chicago, Ill., changes dies by shifting one die carrier aside on rails built at the floor level and moving the second carrier into working position from the opposite side. Final die adjustments are made quickly with an independent inching drive and a servo-controlled shutheight-setting system.

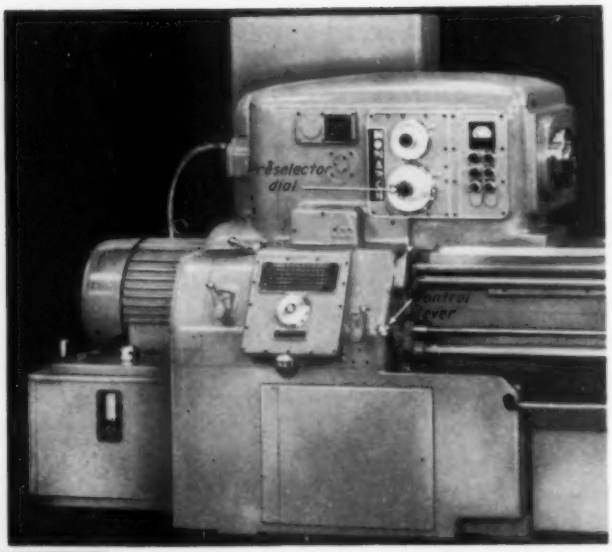


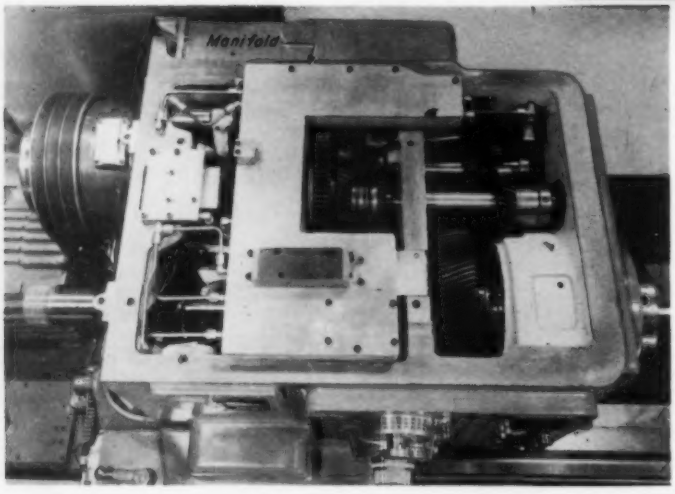
Die carrier assemblies are mounted on wheels . . . which ride rails extending out through openings between the press columns. They are moved in and out of the press by motor-driven chain conveyors located just below the floor. Carrier motion is controlled by pushbuttons on the press control panel; interlocks prevent damage by de-energizing the chain drive when the carirers approach a preset minimum separation. Inside the press, the carrier is positioned against a positive stop. Hydraulically operated rail sections, positioned under each wheel, lower the carrier to seat the bolster solidly on the press bed. Then, hydraulically operated clamps automatically fasten the upper die half to the press slide. Shutheight of blankholder and slide are set up with a potentiometer-controlled servo system which positions them with a repeatability of 0.002 in. with no overtravel. Trial strokes are made with an inching drive, independent of the flywheel and easily reversed. When inching drive operates, press brake functions as a clutch.





Sandwich Manifolds Replace Piping



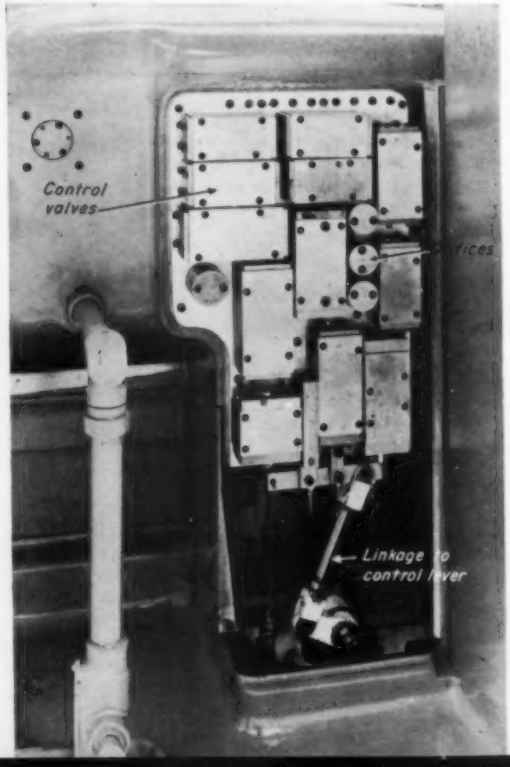


Hydraulic control valves, in functional groups, are on sandwich manifolds in the automatic-speed-shifting headstocks of series-62 lathes built by the Monarch Machine Tool Co., Sidney, Ohio. Resulting compactness simplifies assembly, and absence of exposed connections prevents piping errors or leakage caused by vibration in service. Dials on headstock facilitate preselection of 36 spindle speeds from 14 to 1750 rpm.

While lathe is making a cut, . . .
operator can preselect optimum spindle speed for next cut. The compound dial he uses is calibrated in surface speeds and workpiece diameters. A single lever controls shifting and spindle rotation with three positions: Run, Brake and Jog; speed change takes place in Jog position.

Hydraulically shifted gear drive was selected as best for obtaining a wide range of surface speeds together with single-knob speed selection and foolproof operation. Resulting sequence controls and interlocks formed a complicated hydraulic system with many cross-connections, and led the designers to sandwich manifolds with circuits on both sides of a center core plate. Major problem was to develop a satisfactory manifold. Aluminum plates, brazed with an aluminum alloy, were finally selected for inertness and workability.

Holes drilled in headstock casting connect the manifold assemblies, and only those components which must be separated from the manifolds are connected with piping. All circuit joints are sealed with O-rings. Control valves with different porting arrangements have different mounting-hole configurations to prevent installation errors.

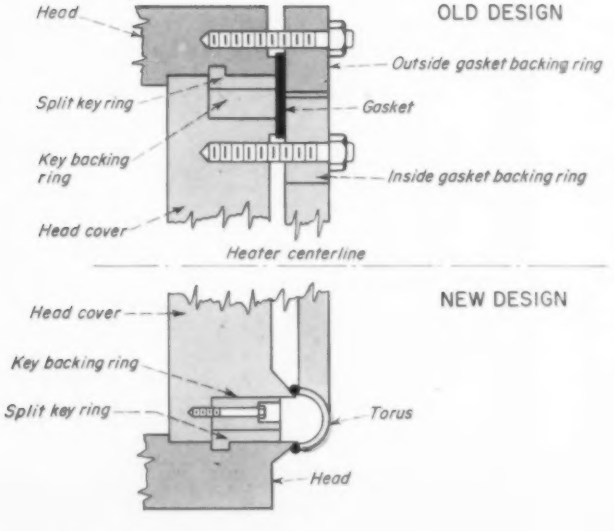


Lift Truck For Long Hauls

A semitrailer truck for lifting and hauling loads up to 5 tons has been designed by the Wumag Waggon und Maschinenbau Gmbh., Krefeld, West Germany. Trailer body, cradled between booms, is positioned hydraulically from ground level to a height of 9 ft.

Lifting booms and stabilizing links . . . are mounted on a yoke-shaped frame which has thick-walled steel tubes for crossmembers. The booms are connected by a tubular torsion bar to synchronize motion of the hydraulic lifting cylinders. Oil pressure is supplied by a gear pump driven by the tractor motor, and flow-control valves limit speed when load is lowered. Trailer wheels are on axles carried in yokes. These yokes are pivoted on the frame and suspended on helical springs.

Welded Torus Seals Water Heater

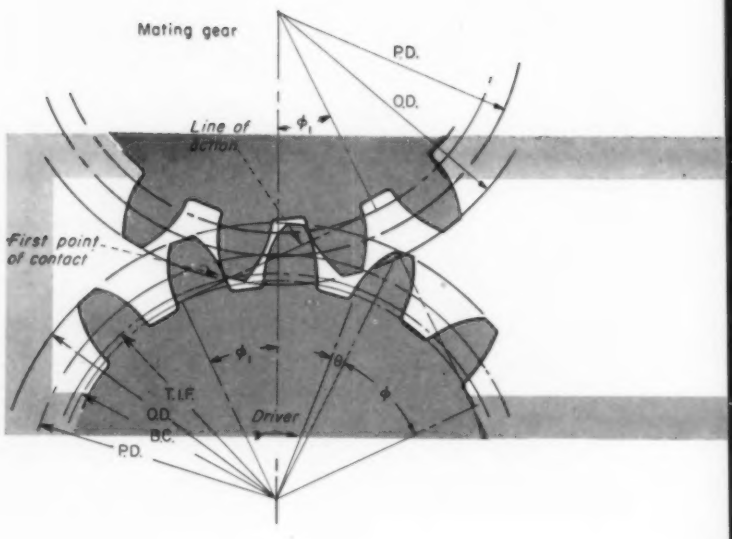


Heads of feedwater heaters are sealed with steel torus sections welded to head and head cover. Made by the Lummus Co., New York City, four high-pressure heaters of this design are being installed in the new Linden Generating Station of the Public Service Electric and Gas Co. of N. J.

Joint sealed with welded torus . . . requires no gasket or studs. In older design, joint was sealed by a gasket backed by two rings, with outer ring bolted to the head, and inner ring to the head cover; on a 50-in.-dia head, about 56 studs were required in the outer ring and about 40 in the inner ring. In both designs, force on cover is absorbed as shear stress in a split key ring. To facilitate internal maintenance, Lummus designed a special tool that cuts the outer seal weld. For Linden installation, water pressures inside head covers are between 3200 and 3600 psig.

Involute geometry . . .

PD, pitch dia
OD, outside dia
BC, base circle dia
TIF, true involute form dia
ϕ, pressure angle
ϕ_1, normal pressure angle
$\theta + \phi$, degrees rolled off base circle



PROFILE DIAGRAMS . . . a graphical way to

LeROY S. HARRIS

Manager, Research & Development
Schutte & Koerting Co., Cornwells Heights, Penn.

Troublesome gears? Here are tips on tooth-profile tolerances and how to turn them into specifications that will control errors when the gear is being made.

High accuracy can be assured, the next time you design gearing, by including a profile diagram on the gear drawing. This ties down just how much error is acceptable, and in addition makes profile checking easy for the inspection department.

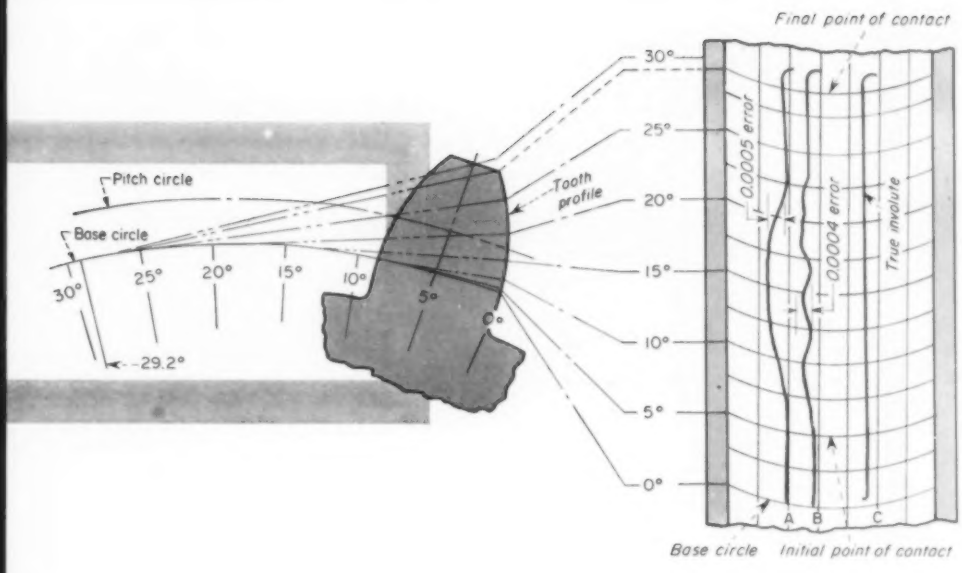
Profile errors are deviations from the "true" involute of a gear tooth. They are caused by distortion in heat-treating after machining, by inaccurate gear-generating cutters, or by errors in setups or machines. The gear manufacturer can hold these errors to a minimum by selecting the proper heat-treating process, by adequate inspection methods of the machine setup, and by grinding, lapping or shaving the tooth profile after heat treating.

It is not hard to spot the errors with a commercial gear checker. The inspector can use a machine that rotates either the gear, the measuring indicator, or both about the base-circle diameter. The profile is recorded on a chart, Fig. 1. A true involute produces a straight line, and deviations can be interpreted in thousands of

TABLE I—Tooth-profile Tolerances for Spur and Helical Gears

(AGMA Standards 231.01, 232.01, and 233.01)

Class No.	Max. Speed, fpm	Diametral Pitch	Profile Error, total variation in 0.0001 in.							
			Pitch Diameters, in.							
			¾	1½	3	6	12	25	50	100
1	—	1	—	—	—	—	50	60	70	80
		2	—	—	—	30	35	40	45	50
		4	—	—	25	30	35	40	40	40
		8	—	20	20	25	25	30	30	—
		16	15	15	15	20	20	25	—	—
2	400	1	—	—	—	—	30	35	40	40
		2	—	—	—	20	20	25	30	30
		4	—	—	10	10	11	12	12	12
		8	—	9	9	9	9	9	10	—
		16	7	7	7	7	7	7	8	—
3	2000	2	—	—	—	11	11	11	11	11
		4	—	—	8	8	8	8	8	8
		8	—	6	6	6	6	6	6	6
		16	5	5	5	5	5	5	5	—
		32	5	5	5	5	5	5	—	—
4	Over 2000	4	—	—	—	5	5	5	5	—
		8	—	—	4	4	4	4	4	4
		16	—	3	3	3	3	3	3	3
		32	3	3	3	3	3	3	—	—



1 Profile errors . . . are reproduced on chart by a profile checking machine. Waves in line represents deviations from "true" profile. Vertical scale is in "degrees rolled off base circle"; horizontal scale in inches. In these typical curves, tooth profile A has a higher total error than B, but is preferable for its gradual slope.

specify gear errors

TABLE II—Typical Tooth-profile Tolerances from Various Gear-finishing Methods

Gear Finishing Method	Diametral Pitch	Pitch Dia, in.	Profile Error, in.
Grinding (Precision Gear)	6 to 12	1	0.0002
	6 to 12	7	0.0003
	12 to 24	1	0.0002
	12 to 24	7	0.0003
Shaving (Precision Gear)	6 to 12	1	0.0003
	6 to 12	7	0.0004
	6 to 12	20	0.0006
	12 to 24	1	0.0002
	12 to 24	7	0.0003
Hobbing or Shaping (Well-cut Gear)	6 to 12	1	0.0004
	6 to 12	7	0.0005
	6 to 12	20	0.0007
	12 to 24	1	0.0003
	12 to 24	7	0.0004

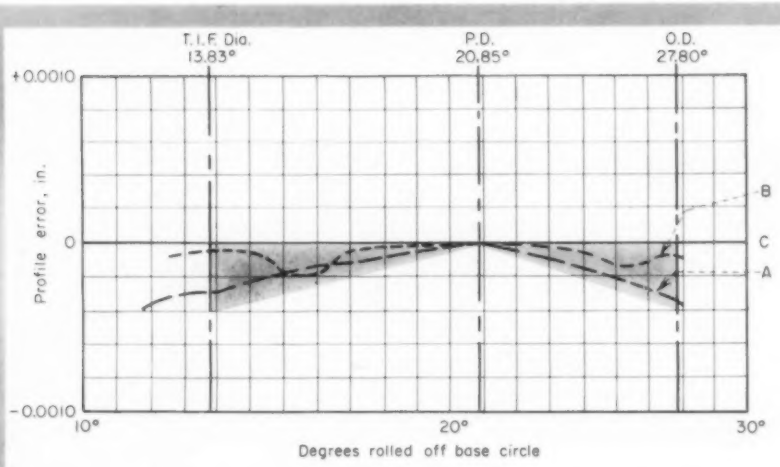
an inch. (Distance between lines on the chart represent 0.0004 in.). Other methods employ optical comparators or micrometers to measure tooth thickness at various tooth heights.

Permissible deviations, Table I, have been established by AGMA (American Gear Manufacturers Association) and are based on the class of precision, diametral pitch and pitch dia of the gear. In addition, Table II gives typical tooth-profile tolerances obtainable by various gear-manufacturing methods.

WHEN A DIAGRAM IS USEFUL

No notation is needed on the drawing for ordinary commercial-grade gears where profile errors of 0.0015 to 0.003 in. or greater are permissible. But for more accurate commercial-grade gears made on gear hobbing or shaping machines, errors can be within 0.0005 to 0.001 in., and limits on the involute error should be specified.

For precision-grade gears or for critical applications where the reliability or noise of a gear is a major factor, the maximum errors should not exceed about 0.0005 in.; and the rate of change or slope also should be specified, preferrably with a profile diagram. It plots the range of permissible error vs degrees rolled off the base circle, and can take the form shown in Fig. 2, which simulates an actual chart, Fig. 1, that was obtained by using an involute-checking machine. The profile diagram quickly conveys to the gear inspector or manufacturer the permissible departure of the profile from the true involute. The horizontal scale is calibrated in degrees rolled off the base circle dia, $\theta + \phi$, with



2 Profile diagram . . . simulates typical curves in Fig. 1, in a form convenient to use on a gear drawing to tie down tooth profile errors. Area in color represents permissible deviations from true involute. A gear represented by line *B* would be rejected by notation requiring error to be proportional to distance from pitch dia.

NOTE: With indicator reading zero at pitch dia. Involute profile error must be within limits shown. Variation of profile line from true involute must be proportional to distance from the pitch diameter.

values ranging from zero at beginning of the involute on the base circle, to a maximum when the involute tooth position is at the OD.

The true involute form (TIF) dia corresponds to the lowest point along the tooth at which contact occurs. This point can be determined graphically, or analytically from the intersection of the OD of the mating gear and the line of action. Actual tooth contact along the involute profile (and the range to be checked) occurs between the TIF dia and the OD, assuming there is no chamfer along the outer tip of the tooth. These limiting boundaries are also noted on the profile diagram to indicate the limits of the tooth contour included in the involute profile specifications.

The pitch dia (PD) position on the diagram is a reference or zero position on the profile from which the direction of profile error is measured or specified with a positive or negative value. For convenience, an explanatory note is added under the diagram.

A better picture of the permissible-error range can be given by shading these areas on the diagram. The colored area in Fig. 2 indicates a negative permissible profile error of 0.0004 in.; in some designs it might be desirable to permit only positive errors. Profile errors both positive and negative would be indicated by shaded areas on both sides of the zero line. For this condition the total permissible profile error would be the sum of the negative and positive values.

SLOPE OF PROFILE CURVES

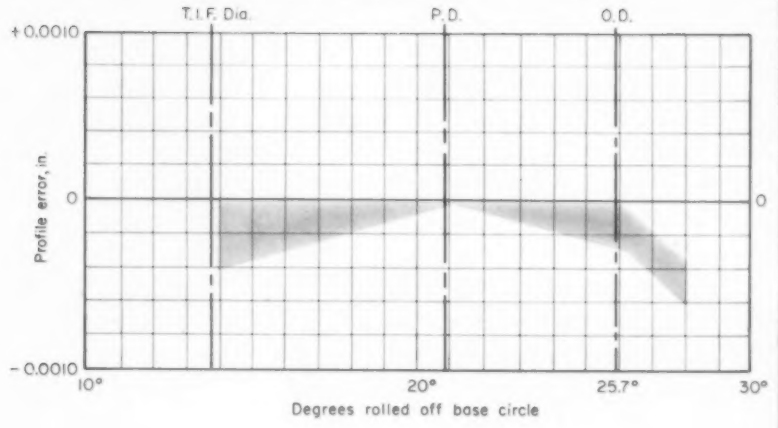
The slope of the deviations in the tooth profile is not covered by AGMA specifications. Curve *B* in Fig. 2 shows a profile which falls within the shaded area but sharpness of the "bumps" may cause undesirable vibrations or undue wear. To control this type of error, the notation under the diagram should state limits for the slope of the profile with reference to the true involute, as in the example shown in the profile diagram above.

PROFILE MODIFICATIONS

By relieving the tooth tip to give a little clearance at the first point of contact, gears run quieter and carry more load. This or any other profile modification can be effectively specified, as in Fig. 3. The chamfer in the colored area near the tooth tip indicates that a deviation from the true involute profile is desired within the limits and dimensions shown.

SIMPLIFIED DATA SHEET

In specifying the angular position of any point on the involute profile in terms of "degrees rolled off base circle," calculations can be reduced to routine by the method shown in Table III. Calculations are shown for a typical spur gear. The data at the head of the table, such as BD = 4.229 and TIF = 4.350, are established from the basic calculations on the gear along with other pertinent data such as the addendum, dedendum, etc. The angular position of the three specific points is found to be: PD, 20.854°; OD, 27.800°; TIF dia, 13,826°. Then by selecting the desired tolerance from Tables I and II or from specific design requirements, the profile diagram is added on the gear drawing.



3 Profile changes . . . such as tooth tip chamfer can be specified in the diagram. Positive errors would be designated by shaded area above zero line.

EDITOR'S NOTE: The emphasis on precision in gears to increase load capacity, reduce chatter and assure reliability has led to recent reappraisals of methods for specifying gear accuracy. The profile diagram is one method; other methods are described in:

"Tolerances for Over-pin Gear Measurement," May '57, p 194. How to convert AGMA specifications for backlash and tooth-to-tooth composite errors to tolerances for over-pin measurements.

"Methods for Specifying Precision of Spur Gears," Nov '56, p 135. Analysis of AGMA and modified AGMA methods for determining accuracy by rotating the gear with a master gear.

Recent articles on other phases of gear design:

"Epicyclic Gears for Control Mechanisms," Feb '57, p 194. Unusual arrangements of epicyclic gear systems with only two gears, for light-duty high-reduction mechanisms.

"Stress Cycles in Planetary Gears," Jan '57, p 219. Charts and formulas for calculating the stress cycles that a particular gear tooth receives during desired life.

"Measurement and Control of Chatter in Gear Drives," Dec '56, p 168. Chatter analysis by instrument; equations for computing speed variations and eccentricity; recommendations for gear reducers and drive motors.

"Finished-forged Gear Teeth Now Used in German Autos," May '56, p 180. New process requires no machining.

Spline Problems?

As with gears, involute splines also present questions of tolerances. A coming article will give latest design data on such splines. It will cover popular forms, fits and tolerances; also give charts for estimating size and capacity, and a run-down on today's spline practices.

TABLE III—Gear Design Data Sheet

PD = 4.500 OD = 4.700 $\phi_1 = 20°$
BD = 4.229 TIF dia = 4.350

At Pitch Dia

$$\cos \phi_P = \frac{BD}{PD} = \frac{4.229}{4.500} = 0.940 = \phi_P = 20°$$

$$\theta_P = \text{INV. } \phi_P \times 57.3 = 0.015 \times 57.3 = 0.854$$

Therefore $\phi_P + \theta_P = 20.854$

At Outside Dia

$$\cos \phi_E = \frac{BD}{OD} = \frac{4.229}{4.700} = 0.900 = \phi_E = 25.883$$

$$\theta_E = \text{INV. } \phi_E \times 57.3 = 0.033 \times 57.3 = 1.917$$

Therefore $\phi_E + \theta_E = 27.800$

At T.I.F. Dia

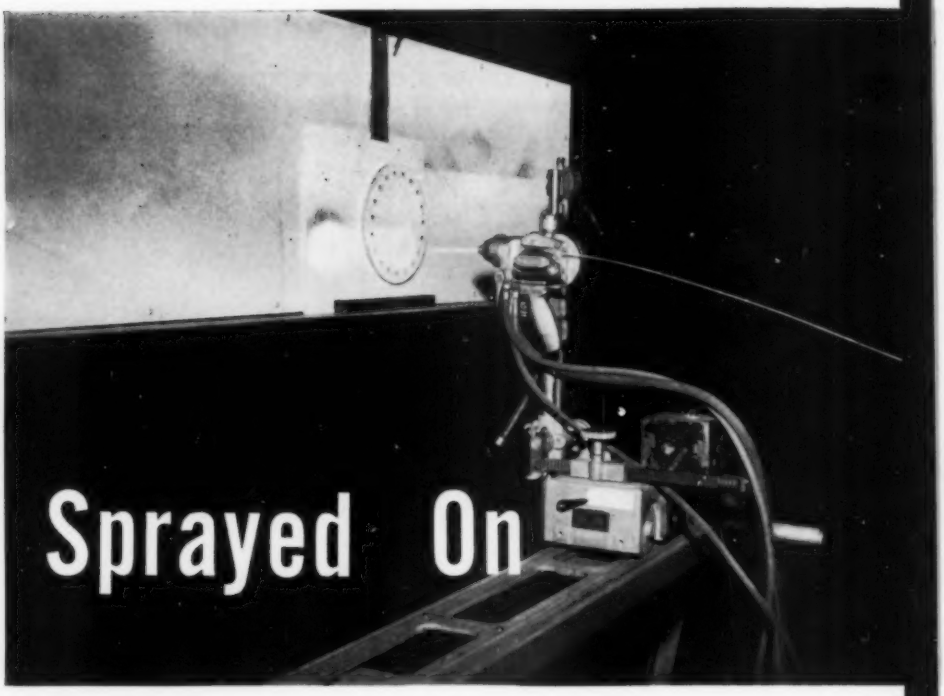
$$\text{cos. } \phi_Z = \frac{BD}{Z} = \frac{4.229}{4.350} = 0.972 = \phi_Z = 13.567°$$

$$\theta_Z = \text{INV. } \phi_Z \times 57.3 = 0.0045 \times 57.3 = 0.259$$

$$\phi_Z + \theta_Z = 13.826$$

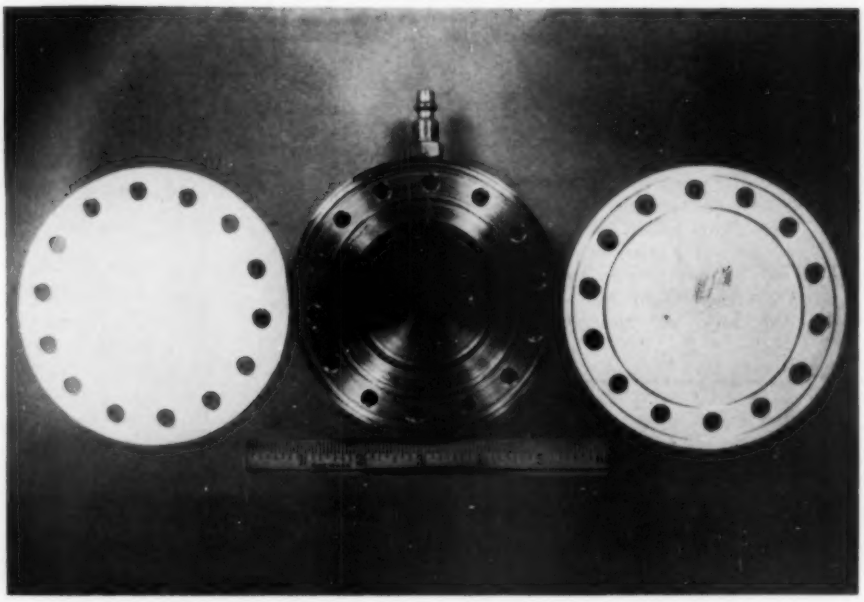
These Gaskets are Sprayed On

R. E. WAGNER
Producibility Unit, The Martin Company



Pressure-vessel cover . . .
is coated with a sprayed-aluminum gasket by standard wire-metallizing technique. Uniform gasket thickness, a key factor, is controlled by spray-gun traversing mechanism.

Flanges with large diameters aren't easily sealed, especially where temperature changes are troublesome. This new technique uses a standard metallizing method to coat coverplates with aluminum



The same coverplate . . .
with sprayed gasket before (left) and after bolting to beaded flange. Note impressions of beads on coverplate after removal (right).

New technique for sealing large flanged openings in tanks, bulkheads and piping uses a coating of aluminum sprayed on the coverplate, without need for an inserted gasket. Conventional gaskets for large-diameter openings often require splicing because of size limitations. When sealing fluids at low temperature, ductile gasket materials are limited to the fluorinated hydrocarbons such as Teflon and Kel-F, or combinations of these with asbestos fiber. With soft metals such as copper, sealing pressures are excessive for large diameters, even with tongue-and-groove construction.

In contrast, the sprayed-aluminum gasket has the advantage of an unspliced seal, and the ductility required for low-temperature applications. Developed initially for guided-missile fuel tanks, the method is useful in any equipment handling low-temperature fluids—pumps, automatic valves, reservoirs, surge cylinders, and couplings.

Components of the closure are two flat, mating surfaces. One surface has two parallel tongues or beads which are rectangular, about 0.040 in. wide by 0.032 in. high, and are machined into the flange—one inside the bolt circle and one outside. Spray goes on the flat mating cover plate, using standard metallizing technique with type 1100 aluminum alloy built up to 0.032-in. thickness. To prevent oxidation, inert gas is used to carry the molten aluminum.

Critical factors in obtaining leak-free seals by this method are bolt spacing and uniformity of bolt tightening. Optimum bolt spacing is about 1 in. for any diameter of opening. In setting bolt pressure, a torque wrench or pre-load washers are desirable, and bolts should be tightened in stages. Flange and cover-plate thicknesses established by the ASME Unfired Pressure Vessel Code will hold sealing-load distortion to a satisfactory level. Light sanding of the metallized aluminum gasket surface is sometimes necessary to remove peaks resulting from local overloading by the spray gun.

Metallized aluminum gaskets can be applied to many structural metal bases, but mating flanges should be made of material with similar expansion coefficients. Aluminum joints and stainless joints have been successfully sealed with this method.

Spraying procedure is straightforward, but certain precautions must be taken to obtain optimum adhesion and prevent spalling during large temperature changes, as in liquid-oxygen immersion: (1) The surface being metallized must be lightly sandblasted, using grit that is clean and free of oil and grease; (2) the surface must be preheated and controlled at 250 to 300 F; (3) spray-gun travel must be mechanized to insure uniform coating thickness; and (4) the aluminum spray must be applied in an inert-gas stream. Copper coatings can be applied to steel, but not to aluminum because of intermetallic corrosion.

Re-use of the joint is limited because the sprayed coating deforms permanently each time the seal is made. With care, however, a joint may be coupled and uncoupled three or four times. A severe nick in the machined beads, caused by a dropped tool for example, could render the joint useless.

EDITOR'S NOTE: Other recent articles on deposited metal coating include:

"Flame Plating for Wear Resistance," Sept. '56, p 202. Hard surfacing by detonation compared to other processes; surface finish, preparation of parts, cost data and limitations of process.

"New Developments in Sprayed Metal Coatings," June '56, p 194. Discusses new metal alloy and ceramic coatings now possible by advances in powder-spray gun design. Typical properties of wire-sprayed coatings.

Simulated fuel tank . . . for guided missile is made of stainless steel, has a 30-in. diameter and a 12-in. opening. Beads are machined in tank flange, and coverplate is metallized. Seal with sprayed-aluminum gasket was temperature cycled by partially filling tank with liquid nitrogen (—320 F) and pressurizing to 45 psi with helium to detect leaks. Three successive cycles of closing, cooling, pressurizing and opening showed no leakage.

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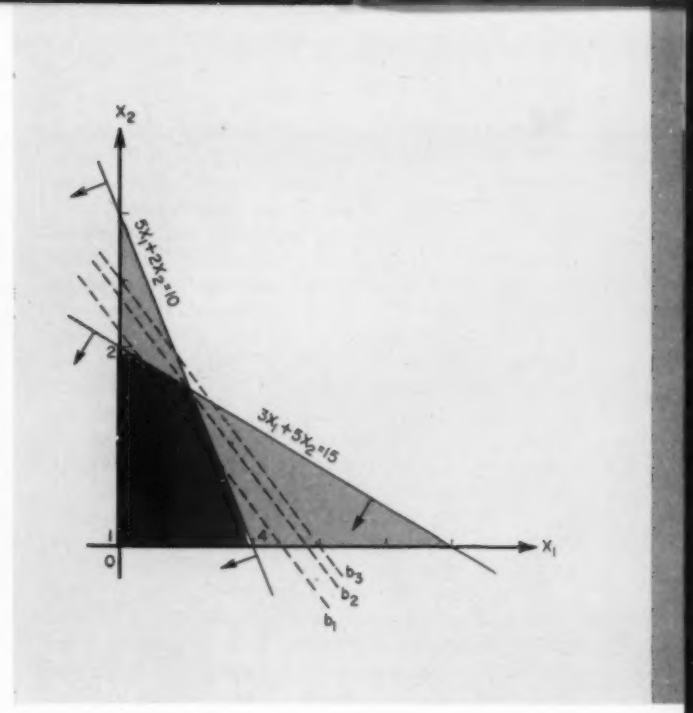
If a problem can be solved more than one way, how do you pick the best alternative? Linear programming may help.



Too Many

Most problems presented to engineering management ordinarily have too many—not too few—possible solutions, and making a single choice among the many alternatives may be even more ulcer-provoking than having no answers at all.

Mathematicians are developing a method that will help choose the most profitable or least costly alternative out of a large (perhaps infinitely large) group. The method is called linear programming.

The word *linear* places an important restriction on applicability of the method. All relationships between variables must be directly proportional. If the amount of a resource is doubled, so is its cost. Relationships cannot, for example, depend on the square of a variable. Some attempts have been made to study nonlinear programming, with little success.

To aid in visualization, here are three general areas into which many solvable problems fall.

Mixing problems involve a number of components, combined to form one or more products. The "mixing" may or may not involve a physical combination of components, but the final product will be a linear mixture of its component parts.

Gasoline blending is a good example. A number of raw stocks are to be blended to yield several grades of gasoline. The quantity of each raw stock available per day is known. In what quantities shall they be mixed (to meet the three or more gasoline specifications) to maximize profits? A further restriction might include the proportion of premium gasoline to regular.

Transportation problems call for the cheapest way to move a product from a number of origins to a number of destinations. Shipping cost between any two points is known. You also know the stock at each origin and the number desired at each destination.

Allocation problems attempt to determine optimum product mix and machine assignments for a given plant. How much of each product should be made and on what machines? Note that sequence or order of performed operations are not considered.

Blanket manufacture, for example, requires that each go through a number of machines, but several different machine combinations can be used. Each machine operates a limited time every day and sales restrictions determine maximum and minimum quantities of blanket types.

Personnel assignment is also a form of allocation problem. A number of men are available with given abilities (job categories). A number of jobs are available. Productivity of the men in each job is known. What assignment has best productivity.

GENERALIZATION AND GRAPHICAL INTERPRETATION

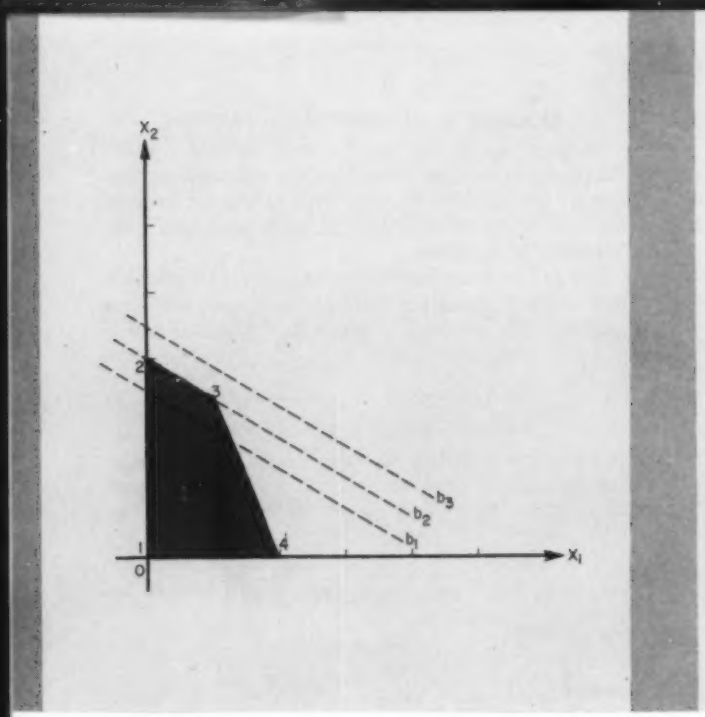
The general linear programming problem has n variables X_j which are non-negative

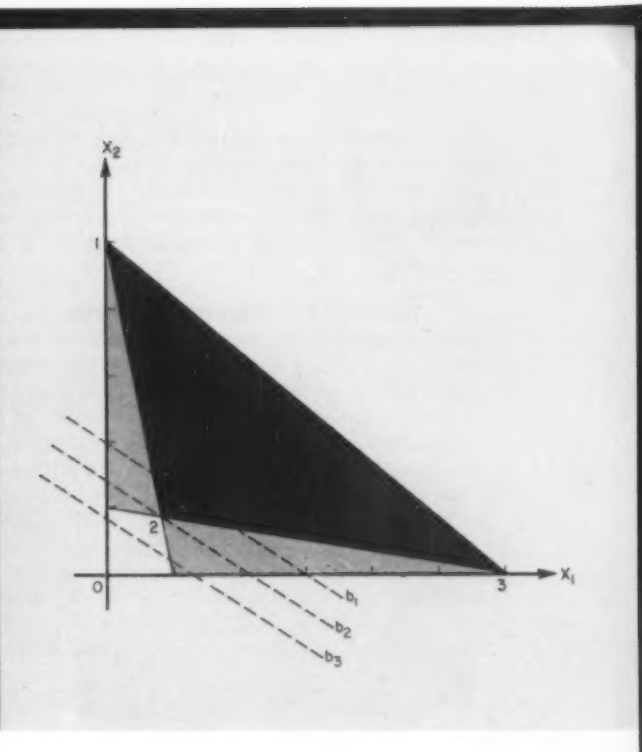
$$X_j \geqq 0$$

and m constraints ($m < n$, in general) of the form

$$a_{i1}X_1 + a_{i2}X_2 + \cdots + a_{in}X_n \geqq b_i$$

with any one of the relationships (equal to, greater than, or less than) possible.





Solutions

It is desired to maximize or minimize a function of the form

$$\sum_i c_i X_i = c_1 X_1 + c_2 X_2 + \cdots + c_n X_n$$

These equations have a geometrical interpretation. A simple two-dimensional (two variables) problem might be defined by

$$X_1 \geqq 0, \qquad X_2 \geqq 0$$

with the constraints

$$3X_1 + 5X_2 \leqq 15 \tag{1}$$
$$5X_1 + 2X_2 \leqq 10 \tag{2}$$

Now maximize

$$b = 4X_1 + 3X_2 \tag{3}$$

Eq (1) and (2) are plotted in Fig. 1 and, because X_1 and X_2 must be positive, the inequalities limit the variables to areas between the straight line and axes. The combined area (in color) satisfies both inequalities and it therefore represents a feasible solution.

For any given value of b in Eq (3) a straight line can be constructed for values of X_1 and X_2. Two values of b will set up parallel straight lines, then b is varied with its line moving up and to the right until the largest value of b is obtained whose line still has at least one point in the shaded area (b_3 in Fig. 1). This point represents optimum values of X_1 and X_2.

Solutions to linear programming problems always occur at one corner of the area containing allowable solutions. The area in Fig. 1 has four extreme points. The simpler method for solving these problems is a procedure for moving from extreme point to extreme point until the optimum is reached.

Suppose Eq (3) were altered to read

$$b = 1.5X_1 + 2.5X_2$$

This equation has been plotted in Fig. 2 for some values of b. Note that here a group of values of X_1 and X_2 will all satisfy the requirements although there is a unique value for b.

A minization problem is shown in Fig. 3.

$$X_1 \geqq 0, \qquad X_2 \geqq 0$$
$$5X_1 + X_2 \geqq 5$$
$$X_1 + 6X_2 \geqq 6$$
$$X_1 + 1.2X_2 \leqq 6$$
$$2X_1 + 3X_2 = b$$

The three constraint inequalities limit the area to a triangular shape. The minimum b occurs at point 2.

AIDS TO SOLUTION

It should be evident without considering the mathematical methods in detail that a problem of any size (say, 20 equations and 50 variables) would require a tremendous amount of time to work out by hand. Simpler problems can, of course, be solved by any one of several methods, and there are many published papers describing such methods in detail (see references on the next page).

Codes for high-speed digital computers have been developed for the solution of linear programming problems. At least four programs are available for the IBM 650 and one of them will, in theory, handle

up to 98 restrictions. It is possible to have up to 200 restrictions in the IBM 704.

Note that the decision to undertake a linear programming study usually entails fairly heavy expense. Potential savings must be reasonably large to justify such a study.

EXAMPLE I—GASOLINE BLENDING

To help establish the essential character of linear programming here is a symbolical presentation of some problems with an indication of how to solve them.

In gasoline blending, assume three raw stocks (A, B and C barrels available per day for blending into two grades of motor fuel. Let X_{ij} ($\geqq 0$) be the gallons of raw stock j blended to form fuel i.

Each fuel must meet three specifications. For these, let a_j be the lean octane number, b_j the rich octane number and c_j the Reid vapor pressure of raw stock j.

Let α_i be the lean octane number, β_i the rich octane number and γ_i the Reid vapor pressure of fuel i.

Availability restrictions set up three relationships.

$$\begin{aligned} A &\geqq X_{11} + X_{21} \\ B &\geqq X_{12} + X_{22} \\ C &\geqq X_{13} + X_{23} \end{aligned} \tag{4}$$

Equal-or-greater-than signs are introduced because it may not be desirable to blend all of any one raw stock.

Blending specifications for lean octane number establish

$$\alpha_1 \leqq \frac{a_1X_{11} + a_2X_{12} + a_3X_{13}}{X_{11} + X_{12} + X_{13}} \tag{5}$$

Here each ratio $X_{11}/(X_{11} + X_{12} + X_{13})$ represents the ratio of raw stock No. 1 in fuel No. 1. Or rearranged

$$(a_1 - \alpha_1)X_{11} + (a_2 - \alpha_1)X_{12} + (a_3 - \alpha_1)X_{13} \geqq 0$$

Similarly for rich octane number and Reid vapor pressure

$$(b_1 - \beta_1)X_{11} + (b_2 - \beta_1)X_{12} + (b_3 - \beta_1)X_{13} \geqq 0$$
$$(c_1 - \gamma_1)X_{11} + (c_2 - \gamma_1)X_{12} + (c_3 - \gamma_1)X_{13} \geqq 0$$

Equal-or-greater-than signs allow for going above the minimum specifications if it is profitable to do so.

A set of three inequalities may be based on the three specifications for the ith motor fuel in the general form

$$(a_1 - \alpha_i)X_{i1} + (a_2 - \alpha_i)X_{i2} + (a_3 - \alpha_i)X_{i3} \geqq 0$$
$$(b_1 - \beta_i)X_{i1} + (b_2 - \beta_i)X_{i2} + (b_3 - \beta_i)X_{i3} \geqq 0$$
$$(c_1 - \gamma_i)X_{i1} + (c_2 - \gamma_i)X_{i2} + (c_3 - \gamma_i)X_{i3} \geqq 0$$

Let λ_i be the revenue made on one gallon of motor fuel i and Ψ_j the cost of one gallon of raw stock j. Neglecting mixing costs, the profit to be maximized is

$$\sum_{i,j} (\lambda_i - \psi_j)X_{ij} \tag{6}$$

to be summed over i and j. Eqs (4) and (5) set the restraints of the problem, and (6) the function to be maximized.

No sales restrictions were included. Suppose the quantity of fuel 1 cannot be greater than fraction f of all motor fuel made. Then

$$X_{11} + X_{12} + X_{13} - f(X_{21} + X_{22} + X_{23}) \leqq 0$$

EXAMPLE II—BLANKET MANUFACTURE

Suppose $X_i \geqq 0$ is the quantity of blanket material produced on a given combination of machines. Several X_i may refer to the same type of blanket material because a given material may be made on several combinations of machines.

Let $a_{j,i}$ be hours required on machine j to process a unit length of material i. Let b_j be total machine hours available (say, per week) in machine j. Machine restrictions thus become

$$a_{11}X_1 + a_{12}X_2 + \cdots + a_{1n}X_n \leqq b_1$$
$$a_{m1}X_1 + a_{m2}X_2 + \cdots + a_{mn}X_n \leqq b_m$$

These equations state that for n variables (materials) and m machine types the sum of machine time spent on each material cannot exceed the hours available on that machine.

Sales restrictions may be included. Let d_k and e_k be maximum and minimum amounts of each blanket material to be produced

$$\Sigma X_i \leqq d_k$$
$$\Sigma X_i \geqq e_k$$

The summation is taken over all X_i referring to the same blanket.

If C_i is the profit per unit length of blanket X_i then it is desirable to maximize.

$$\sum_i C_iX_i = C_1X_1 + C_2X_2 + \cdots + C_nX_n$$

EXAMPLE III—TRANSPORT PROBLEM

Suppose there are a_i units of a product available at origin i and at least b_j units of the product are to be shipped to destination j. Let C_{ij} be the cost to ship one unit from origin i to destination j. Let X_{ij} be the number of units shipped from origin i to destination j. The restraints are

$$X_{ij} \geqq 0$$

The total amount shipped to all destinations from origin i cannot exceed a_i

$$\sum_j X_{ij} \leqq a_i$$

The total received from all origins at destination j must be at least b_j

$$\sum_i X_{ij} \geqq b_j$$

Now minimize the total cost

$$\sum_{i,j} C_{ij}X_{ij}$$

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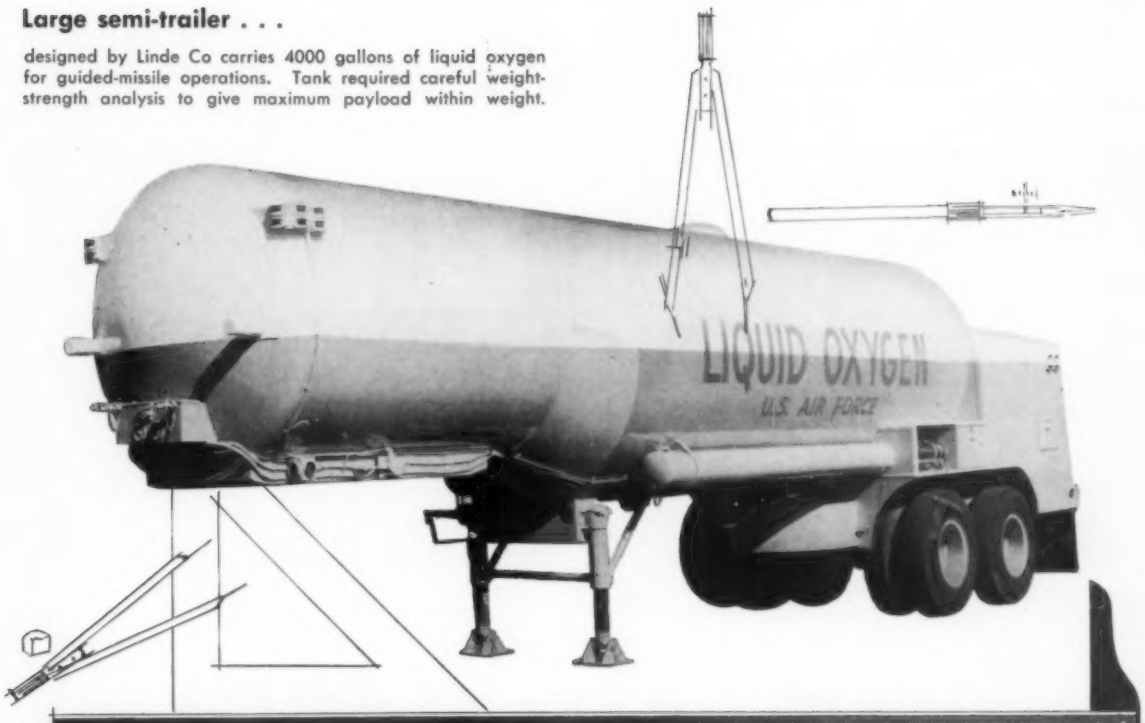
Large semi-trailer . . .

designed by Linde Co carries 4000 gallons of liquid oxygen for guided-missile operations. Tank required careful weight-strength analysis to give maximum payload within weight.



how to construct charts for

Rapid Weight-Strength Analysis of Pressure Vessels

Simple weight-volume ratio formulas for cylinders, spheres and elliptical heads speed designing. Included are recommended proof-pressure stresses for eight commonly used materials, also typical charts for two cases.

R. E. WONG, *Design Specialist, Research Division, Bell Aircraft Corp*

Weight calculations for pressure vessels are often onerous as well as time-consuming. Here is a chart method for rapid optimum weight-strength determination where a series of computations must be made involving different sizes, pressures, and materials—for example, missile propellant tanks, bus air-brake accumulators, transport tankers—wherever weight and space limits are important factors considered early in the design.

To construct the charts as a function of pressure, capacity and material, a definite design-stress level must be selected. One logical criterion is the stress at proof-pressure test—the maximum experienced by any pressure vessel. This stress level depends, of course, on the pressure test used.

Here it is a volumetric set during hydro-test of not more than 0.1% of total volume, corresponding to a permanent material strain of 0.0005 in./in. for cylinders and 0.0003 in./in. for spheres. The table on page 97 lists recommended stresses at proof pressure for

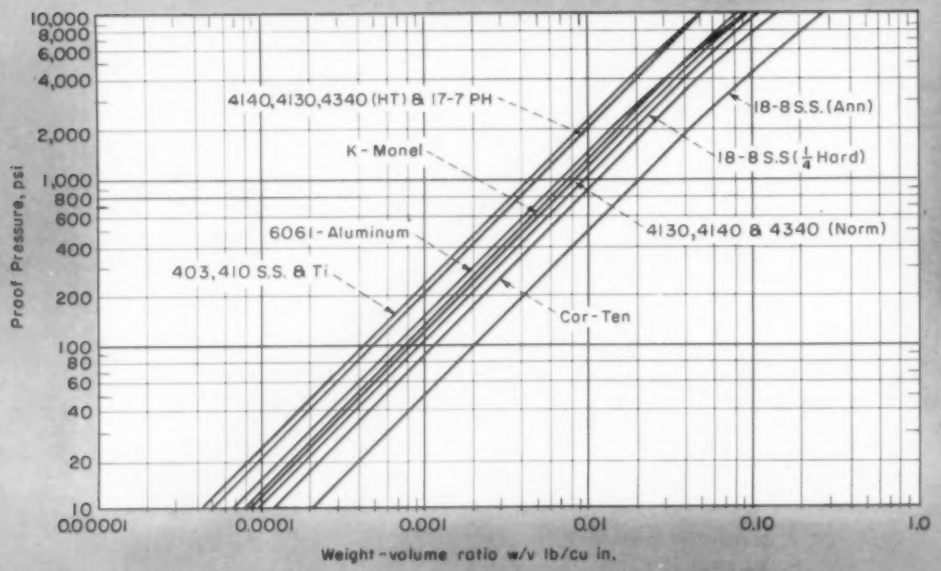


Fig. 1

Weight of cylindrical shells.

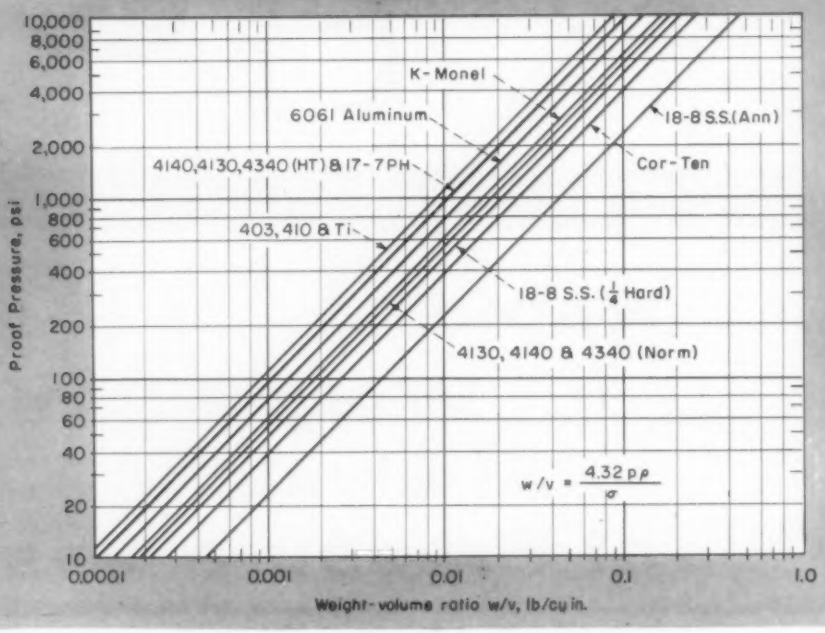


Fig. 2

Weight of elliptical heads for k=2.

eight common pressure-vessel materials. It is based on several years' experience at Bell Aircraft Co.

This chart approach plots internal pressure p (see nomenclature) against the ratio of weight-to-volume W/V, with the proof pressure related to working pressure by an appropriate safety factor. The weight-volume ratio must be calculated separately for the cylindrical shell, spherical shell and elliptical head.

To indicate method, calculations below are shown only for the cylindrical shell and the elliptical ends, with the sphere W/V ratio given separately. Design charts in Figs. 1 and 2 are for the shell and for the elliptical head with ellipse ratio $k = 2$. Similar charts for spherical vessels and for elliptical heads of different proportions can be easily constructed if needed.

WEIGHT OF CYLINDRICAL SHELLS

When the cylindrical portion is at a sufficient distance from the constrained ends, the maximum stress on the internal surface due to internal pressure is given with reasonable accuracy by the simple hoop membrane formula.

$$\sigma = pa/t$$

Using a mean radius a of $(d + t)/2$, the thickness t may be written

$$t = pd/(2\sigma - p)$$

With the weight of the cylindrical shell given by

$$W = \pi(d + t)l\rho t$$

and the volume given by

$$V = \pi d^2 l/4$$

the ratio of weight-to-volume is simply

$$W/V = 4(d + t)\rho t/d^2$$

By eliminating the shell thickness t, the ratio is expressed in terms of pressure p and stress level σ

$$W/V = 8\rho\sigma p/(2\sigma - p)^2$$

with a further simplification when p is small compared to 2σ

$$W/V = 2\rho p/\sigma$$

The shell weight is independent of length and diameter, so for a given volume, the weight does not depend on the number and size of the containing vessels. But the weight of such items as tank ends, baffles, lines and fittings, and support structures must be included for a realistic weight comparison.

Using the unsimplified W/V equation above and the proof-pressure stress levels given in the table, the rapid-calculation chart of Fig. 1 is constructed. The chart is entered at the proof-pressure ordinate, traversed horizontally to the appropriate material line, and W/V is read from the abscissa.

WEIGHT OF ELLIPTICAL ENDS

Analysis of pressure-vessel heads is usually divided into knuckle region and crown region. In the knuckle, circumferential compressive stresses exist which may cause buckling; in the crown, tensile stress governs. Experience shows the length of the knuckle region is approximately one-fourth the radius of the cylindrical shell. Thus, a close head-weight approximation is possible by assuming an equivalent head thickness equal to the average thickness of knuckle and crown.

Stresses at the junction of knuckle and crown are usually much less than those in the critical portions of the knuckle and at the crown center. Consequently, allowable stress used to determine knuckle and crown thickness should be that of the base metal and not that of the weld, if welding is done at the junction of knuckle and crown.

The weight-volume ratio for elliptical heads can be constructed following the procedure for shell. Detailed analysis of knuckles in heads under internal pressure shows that the maximum stress can be written in a form similar to the hoop-stress formula for shells

$$\sigma = Kpa/t_k$$

where K is a stress factor for a particular ellipse ratio k as shown in curve at Fig. 3. Maximum stress at the center of the crown is similarly

$$\sigma = pR/2t_c$$

and since the crown radius $R = ka$, the equivalent head thickness mentioned in the text is

$$t_e = (t_k + t_c)/2 = pa(K + k/2)/2\sigma$$

Weight of the heads is most easily determined from the surface area of the ellipsoid formed by both

$$A = 2\pi a^2 + \frac{\pi b^2}{e} \ln\left(\frac{1+e}{1-e}\right)$$

where a = semi-major axis = shell radius
b = semi-minor axis = crown height
e = eccentricity $= \sqrt{(a^2 + b^2)/a^2} = \sqrt{1 - 1/k^2}$

Introducing the density and the equivalent thickness t_e, the total head weight becomes

$$W = \frac{\pi a^3 \rho p}{2\sigma}(K + k/2)\left[2 + \frac{1}{k\sqrt{k^2-1}} \ln\left(\frac{k+\sqrt{k^2-1}}{k-\sqrt{k^2-1}}\right)\right]$$

(Text continues on next page)

NOMENCLATURE

p—internal pressure, psi
W—weight, lb
V—volume, cu in.
A—surface area, sq in.
l—length of cylinder, in.
d—inside dia of cylinder
R—radius at center of crown, in.
a—mean radius of cylinder, in.
t—thickness, in.
t_k—thickness of knuckle, in.
t_c—thickness of crown, in.
t_e—equivalent thickness, in.
b—minor radius of ellipse, in.
k—ellipse ratio $= a/b$
K—ellipse stress factor, dimensionless
σ—stress, psi
ρ—density of material, lb/cu in.

Table—Recommended Proof-Pressure Stresses for Cylinders and Spheres

Material	Condition	Density lb/cu in.	Tensile Strength, psi	Proof Pressure Stress, psi	
				Cylinders	Spheres
18-8 SS	Annealed	.286	75,000	28,000	26,000
18-8 SS	¼ hard	.286	125,000	60,000	56,000
17-7 PH	FA (formed & aged)	.276	170,000	112,000	100,000
4130, 4140, 4340	Normalized	.283	90,000	67,000	65,000
4130, 4140, 4340	Heat-treated	.283	140,000	118,000	115,000
Cor-Ten	Cold-rolled	.284	70,000	48,000	45,000
403, 410 SS	Heat-treated	.280	180,000	126,000	120,000
K-Monel	Age-hardened after welding	.306	134,500	80,000	77,000
6061 Aluminum	Welded in T4 Aged to T6	.098	38,000	28,800*	28,800*
Titanium	Pure-annealed	.163	100,000	70,000	66,000

*Note: Weld strength is limiting factor for cylinder; for head use 32,600 psi.

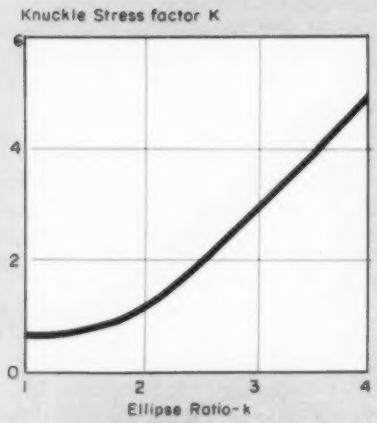


Fig. 3

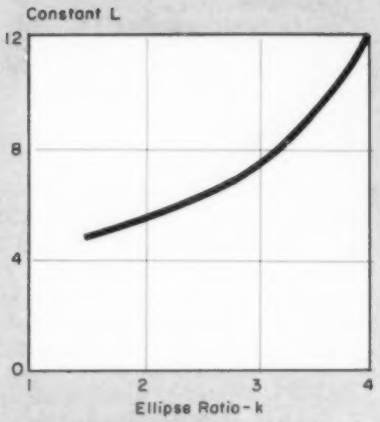


Fig. 4

The volume of an ellipsoid is

$$V = \frac{4}{3}\pi a^2 b = \frac{4}{3}\pi a^3/k$$

The desired weight-volume ratio then becomes

$$W/V = \frac{3\rho p}{8\sigma}(K + k/2)\left[2k + \frac{1}{\sqrt{k^2-1}}\ln\left(\frac{k+\sqrt{k^2-1}}{k-\sqrt{k^2-1}}\right)\right]$$

with the large bracket expressed as a constant L and plotted in curve at Fig. 4.

$$W/V = \frac{3\rho p}{8\sigma}(K + k/2)L$$

For a pair of elliptical heads with diameter ratio $k = 2$, the weight-volume relationship simplifies to the following

$$W/V = 4.32p\rho/\sigma$$

and is plotted in Fig. 2 for the various materials listed in the table. The proof-pressure stresses for cylinders are used with the ellipse equations, because in the volumetric-set method of pressure testing, most of the displacement occurs in the cylinder.

WEIGHT OF SPHERICAL SHELLS

The same procedure for a sphere (or two hemispherical ends on a cylindrical tank) gives the following weight-volume ratio

$$W/V = 96\rho p\sigma^2/(4\sigma - p)^3$$

or, as a close approximation when p is small compared to 4σ

$$W/V = 1.5\rho p/\sigma$$

In constructing a chart for the sphere equation, the proof stress in the last column of the table should be used, corresponding to 0.1% set.

SAMPLE PROBLEM

A 1000-gal annealed stainless tank with 60-in. diameter is closed by elliptical heads with k=2. Compute the tank weight for a working pressure of 30 psi and a 1.5 safety factor.

(1) For a proof pressure of 45 psi, the W/V ratios are found from the charts:

Cylinder .....0.0009 (from Fig. 1)

Head .....0.0020 (from Fig. 2)

(2) Volume of two heads computes to 56,500 cu. in.

(3) Total tank weight is then

W=0.002 (56,500)+0.0009 (1000 x 231–56,500)

W=113+157 = 270 lb

EDITOR'S NOTE: Other recent articles touching on various aspects of pressure-vessel design include:

"Three-Dimensional Photoelasticity," July '57, p 135. An up-to-date evaluation of the best model materials, simplest equipment and most effective methods for practical stress analysis of complex structures. Examples include analysis of a pressure vessel using epoxy casting resin for model.

"Collapsing Pressures of Non-Symmetrical Bodies," Oct. '56, p 165. Equations for an approximate method of calculating collapsing pressures; based on studies of radome structures.

"Photostress," Sept. '56, p 167. A new photoelastic technique for observing and measuring surface strains on actual parts and structures.

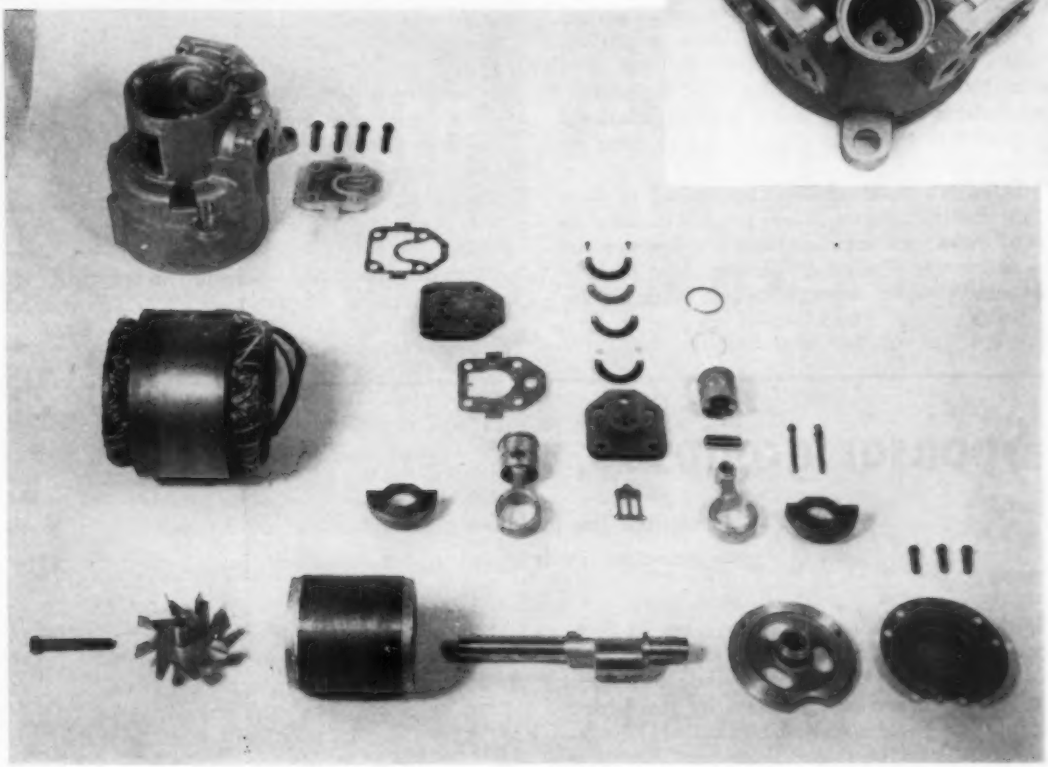
"Predicting Elastic Failures," March '56, p 178. Five requirements for a practical theory for elastic failure; graphical methods for distortion-energy and maximum normal-stress theories.

"Stress Equations for Strain Gage Rosettes," July '55, p 207. This summary of strain-to-stress conversion equations for biaxial stress cases uses four strain-gage configurations: two-gage, rectangular, delta and T-delta.

"Stress Chart for Thick Cylinders," April '54, p 213. Single nomograph for four different circumferential stress equations in cases where ratio of outer to inner radius exceeds 1.14.

Forty-six of 67 major parts . . .

in this hermetic compressor for a room air conditioner are the same regardless of horsepower rating. The housing is now an aluminum-alloy die casting. Over-all weight is cut 20%, inventories are reduced much more.



REDESIGN cuts weight, inventories

E. E. GROVER,
Manager, Compressor Engineering
L. C. PACKER,
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Springfield (Mass) Works, Westinghouse

Shifting from cast iron and bronze to die-cast aluminum, redesigning for die casting and for common use of many parts, tightening manufacturing tolerances to eliminate selective fitting —these are steps in a Westinghouse program that has paid off.

Redesign of the compressor for the new line of Westinghouse room air conditioners cut weight 20%, reduced costs substantially, and made 46 of the 67 major parts common to the four sizes in the line.

Weight reduction was important because room coolers sell better if they are semi-portable. First move, therefore, was to replace the cast-iron housing with an aluminum die casting. But the project was stalled for a time by difficulty in meeting a design objective laid down by the cost-reduction committee (like the one for vacuum cleaners described in May, page 135). It was necessary that two housings cover all four sizes: ½, ¾, 1 and 1½ hp.

Al-380 was the eventual answer; it has good casting properties, is dimensionally stable, easily machined and develops high strength without heat treatment. To give the four sizes, a design was finally developed which was built with either one or two cylinders, with varying stack lengths of a standard motor lamination, and with two refrigerants (F-12 and F-22). Added sizes were ob-

tained by changing the piston and cylinder diameters.

Another important move was to change the connecting rod, end bearing cap and cylinder head to aluminum die castings, using the same alloy. By careful design all four parts were made common to the entire line and cast in multi-cavity dies.

While a single design of valve plate and crankshaft was developed for all sizes, use of aluminum was impractical. The valve plate is shell-molded cast iron, requiring little tooling or machining. The crankshaft is a forging which is rough machined, flame hardened and finish ground to tolerances close enough to avoid selective assembly.

With the two aluminum housings and all of these parts standard for all sizes, it was possible to make 46 of the 67 major parts common to each compressor. Selective fitting was eliminated. Each machine operator is held responsible for inspection; where necessary, finished size is controlled by a running micrometer.

Cooperative study with manufacturing personnel and machine-tool builders minimized the number of machined tools, trial settings and setups. Single setups finish the connecting rod, end bearing, cylinder head and counterweight. This cuts manufacturing area, inventories and supply problems. Die-cast parts are produced as needed by machines installed near the machine tools.

Stator punchings and laminations are the same for all sizes; only stack length is changed in varying the power. Stator cores are annealed to improve magnetic properties. Rotor laminations are annealed in an oxidizing atmosphere to develop an insulating oxide between laminations and the cast rotor bars and end rings. After machining, the rotor is post-heated to break conductors away from the bridge over the slots, and thereby reduce stray losses. Stator insulation is selected to avoid contamination of refrigerant. Wire insulation is polyvinyl acetal enamel; stators are wound automatically.

Sponsor groups . . .

capture the initiative and enthusiasm of an owner-manager in bringing a new product into being.

Effective screening of new product ideas at S. C. Johnson & Son has cut the fatality rate of approved ideas to only about 1 in 10 during the development period, "and we have no fatalities after the product reaches the last marketing phase," Samuel C. Johnson, director of the firm's New Products Department, reported at a recent American Management Association conference.

Johnson's new product department first looks at the elements that make up the profit opportunity of the idea. These include the total market for the product and its growth possibilities, the share of the market that is achievable, and the probable gross profit margin. Next comes consideration of the factors that make up investment in the product, including cost of development, test marketing and introduction expenses, and capital expenditures for plant equipment and tooling. Finally, he said, "we look at some factors we call fit factors, which include distribution fit, production fit, consumer advantages, lead time over competition, and technical difficulty."

The final decision is based on the ratio of investment to profit. "All the fit factors are much like a personality profile used in personnel testing, and you look at them much in the same way. You cannot add up all the personality traits of an individual and, if they numerically come above a certain level, automatically say that this man should or should not be hired.

"The new products function must be a top management one because the decisions involved are of a broad company nature and are important, and because speed is vital. But the right information must be in the hands of the chief operating officer of a large company at the right time to insure any measure of speed."

In addition to top management responsibility, there must be participation at all levels of organization. To promote communication, enthusiasm, and motivation, S. C. Johnson & Son uses "sponsor groups." These problem-solving groups, which meet monthly, follow their products through the commercialization phase. Forty such sponsor groups are now operating, each working on its own new product.

Members of the group may include the man who thought of the idea, the man who is actually going to do the technical work in the laboratory, the man who has to sell the product when it is completed, financial and production staff members if needed, and a member of the new products department.

This technique, said Johnson, provides enthusiasm "because you have identified the man who thought of the idea or is most enthusiastic about it, and have placed him in charge of it. You get a total company view because the important specialized elements of the business are represented. You get cooperation and coordination because these men are working together on a common objective—their assigned product idea. The sponsor group captures all of the basic initiative, drive, and enthusiasm that a one-man operator of a business has in developing his new product."

EDITOR'S NOTE: For a summary of other product-planning procedures representative of the current trend see "Toward a New Design Philosophy," May '57, p 135; also, "Is Your Product Doomed," Sept 9, '57, p 54, which erects nine guideposts to successful product planning.

How to Measure Principal Stresses

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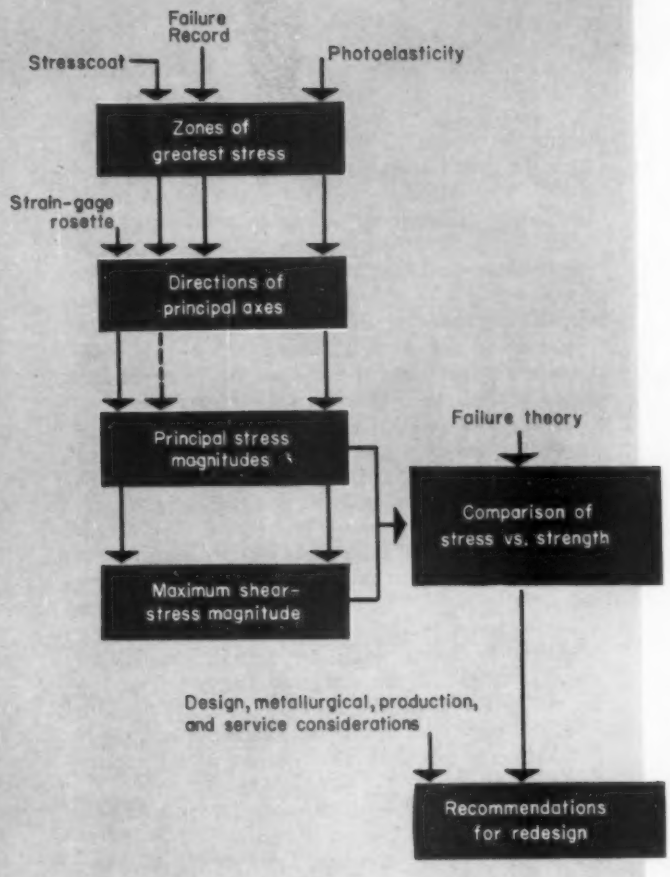
This discussion outlines failure theories in stress analysis, gives distribution patterns for normal stresses, equations relating strain-gage readings and principal stresses, and a method for using only one strain gage to find principal stresses.



1 Procedural steps . . .
in experimental stress analysis.

When a mechanical part fails in service, experimental stress analysis is frequently the next step—so that either the part or the applied loads can be modified. Any comparison of stress vs strength must necessarily be based upon some theory of failure, upon a particular rationale for correlating critical stress from simple uniaxial laboratory tests with critical values of combined stress in the same material.

Stress analysis must: (1) locate the point with greatest stresses, (2) determine direction and magnitudes of these stresses and maximum shear stress, (3) compare applied stress, using the appropriate theory of failure as a basis, with inherent strength of the material, and (4) recommend modifications that will establish a favorable ratio of strength to stress, Fig. 1.

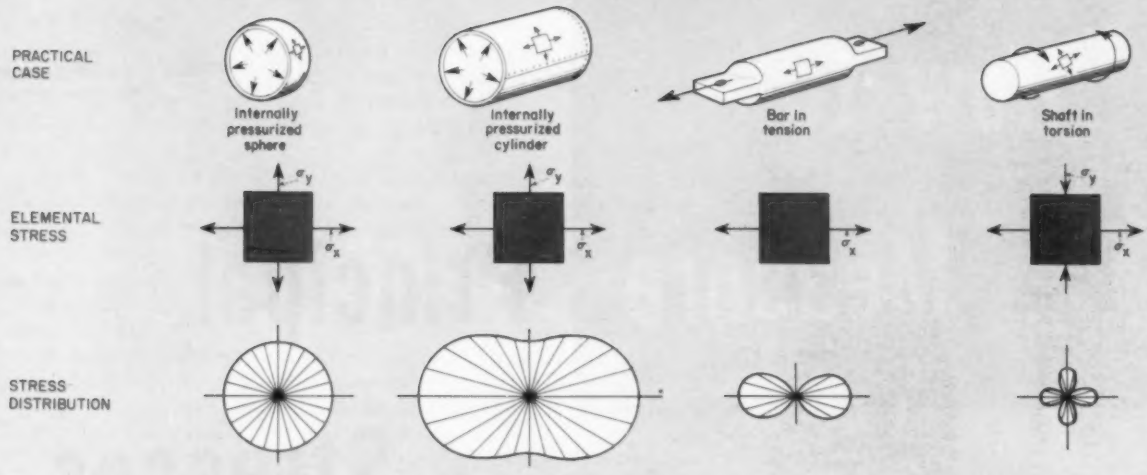
FAILURE THEORIES

These three failure concepts dominate the stress-analysis field:

Maximum-normal-stress theory, assumes that failure will occur in a polyaxial (many-directional) stress field when one of the principal stresses reaches the magnitude corresponding to failure in a simple tension test.

It will predict failures in brittle materials with reasonable accuracy, but is in error when applied to ductile materials.

Distortion-energy-theory, hypothesizes that failure will be imminent when the shear-strain energy equals that at yielding in the conventional uniaxial tension



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test. It gives excellent results for ductile materials but is mathematically complicated.

Maximum-shear-stress theory, presumes that yielding will occur in a polyaxial stress field when the maximum shear stress equals that corresponding to yielding in a simple tension test. It is simple and widely used, although less accurate for ductile materials.

STRESS DISTRIBUTIONS

No matter which failure theory is employed, it is necessary to know the direction and magnitudes of principal stresses. At any point in a biaxial stress field, the maximum and minimum **normal** stresses are at right angles to each other and act on the two orthogonal planes free of shear stresses. The maximum **shear** stress acts on the two planes at 45° to either principal stress and is equal to one-half the difference between the principal stresses.

Normal stress distributions for all possible cases are given in Fig. 2. For more-complex parts, the stress distribution may vary from point to point. Locating the point with the greatest stresses (first of the steps in Fig. 1) can be accomplished in several ways. If parts have been failing in service, the zones of greatest stress may be obvious. With a new part, some form of experimental stress analysis such as Stresscoat or photoelasticity may be necessary to determine the most highly stressed regions. Stresscoat is the more practical technique because it is effective on parts of any shape or contour. It not only points out areas of peak stress, but indicates approximate directions of principal axes, because the brittle lacquer tends to crack along lines normal to the direction of the maximum tensile strain. (*See also photostress technique described in* Sept. '56, p. 167—*ED.*)

Uniaxial stress is illustrated in Fig. 3, where a cylindrical member is subjected to external tension. The stress is the same at every point in the body, ignoring end conditions. Radial distances from the origin to the bounding curves represent normal stress and strain magnitudes in (A) and shear-stress magnitudes in (B) (symbols σ and ϵ represent stress and strain, respectively). The Mohr's circles for stress and strain are also shown (although not necessarily to the same scale) because of their importance in evaluating strain readings. Principal axes are at $\phi = 0°$ (along the load, or y-axis) and at $\phi = 90°$. On these two axes the shear stresses are zero and the normal stresses are either maximum ($\sigma = P/A$) or minimum ($\sigma = 0$). The maximum shear stress acts at 45° from the principal axes and is one-half the maximum normal stress.

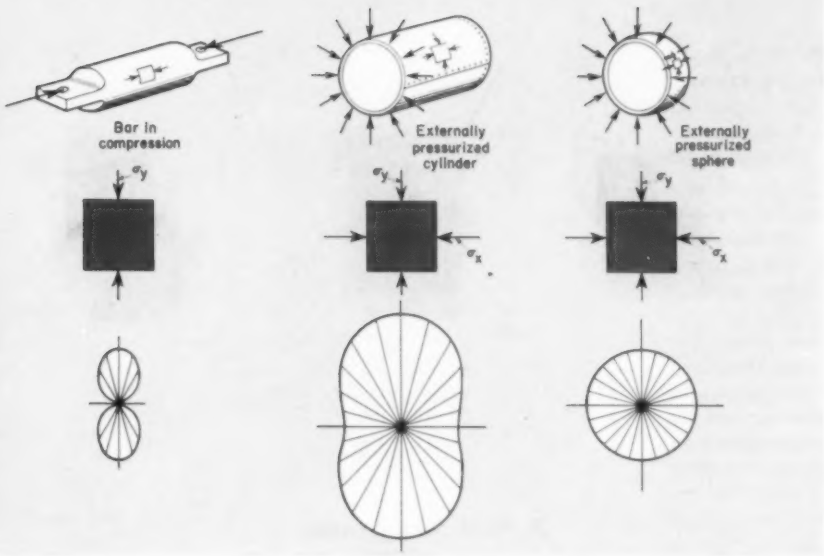
In apparent refutation of Hooke's law there is a strain (negative in this case) at $\phi = 90°$, but without a corresponding stress. This strain is caused by the Poisson's ratio of the material: Longitudinal extension is accompanied by transverse contraction. The various angles can be verified from Mohr's circle, remembering that all angles within the circle are double those on the actual part.

In the more general case of biaxial stress, Fig. 4, where both external loads are tension, the Mohr's circle is shifted to the right and the cusps are less severe. As the maximum shear stress τ_{max} is equal to $\frac{1}{2}(\sigma_{max} - \sigma_{min})$, the shear-stress diagram is unchanged if the difference between the principal stresses remain the same.

It should be noted, however, that a biaxial stress field is actually a special case of a triaxial field in which one of the principal stresses is zero. In Fig. 4, where both principal stresses are tensile, the true maximum shear stress is not $\frac{1}{2}(\sigma_y - \sigma_x)$, but $\frac{1}{2}(\sigma_y - \sigma_z)$ where σ_z is equal to zero. This shear stress will act on a plane at 45° to the plane containing the x and y normal stress.

STRAIN GAGE ROSETTES

Once the regions of peak stress have been located, the bonded wire strain gage should be applied to the problem. Where the directions of the principal axes are unknown, a delta (or tee-delta) strain-gage rosette,



2 Stress distribution . . . for all possible cases of biaxial stress.

3 Bar in tension . . . under a uniaxial stress field (A); normal stress and strain (B); shear stress (C); Mohr's circles (D).

4 Tank under pressure . . . subject to biaxial stress (A); normal stress and strain (B); shear stress (C); Mohr's circles (D).

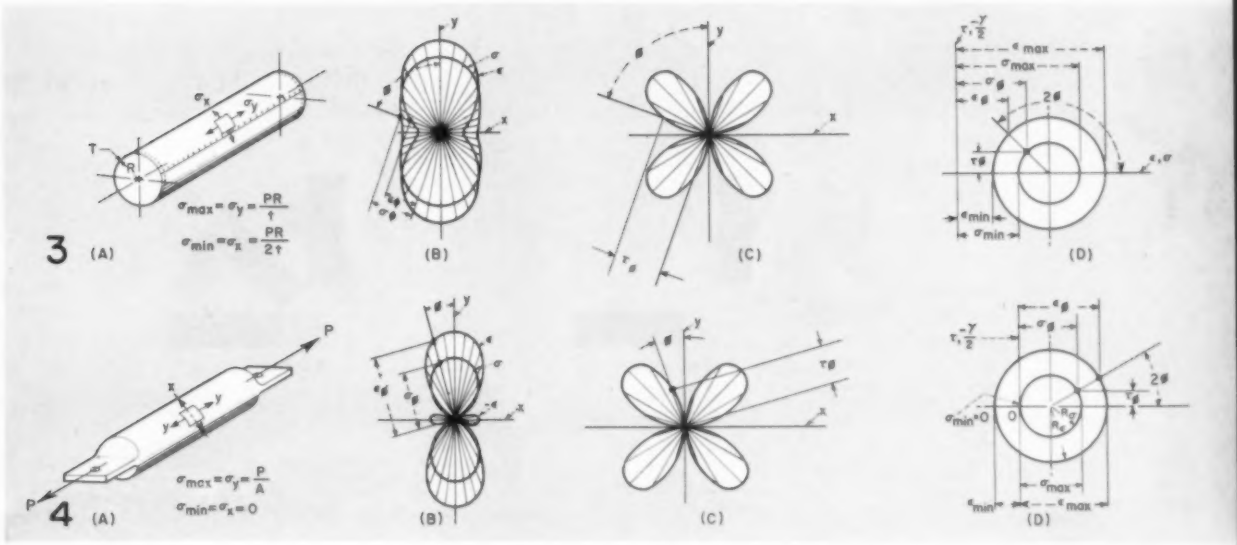


Table I, can be chosen. This rosette has the maximum possible angle between the individual gage elements and gives the greatest accuracy of strain measurement for such a case. It can be mounted in the region of interest with any over-all orientation. The three (or four) indicated strains can be substituted in appropriate equations in Table I to find directions and magnitudes of the principal stresses and maximum shear stress. Symbol μ represents Poisson's ratio; E the modulus of elasticity.

Rectangular rosette, Table I, is applied when the directions of the principal axes are approximately known. It is aligned along the assumed directions of the principal axes, but whether or not the assumptions are correct is incidental to functioning of the rosette, except that the accuracy is slightly improved if gage axes nearly coincide with principal axes.

The two-gage rosette is used when directions of the principal axes are known with some precision. However, even with this arrangement, it is not possible to calculate the principal stresses by merely multiplying the corresponding strains by the modulus of elasticity. Both strains must be measured and substituted in the given equation to calculate either principal stress.

SINGLE-GAGE TECHNIQUES

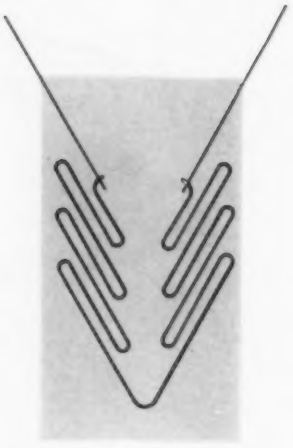
The chevron-type grid, Fig. 5, is so arranged t[hat] normal strains at a point are combined in the correc[t] proportion to give a net change in electrical resistance proportional to the stress (not the strain) along the gage axis. To measure a principal stress, the gage is cemented to the workpiece with its axis oriented along a principal axis. Two gages are required for measuring both principal stresses. As the angle of the chevron is a function of Poisson's ratio, the gage should be applied only to the material for which it is designed.

Principal stresses can be indicated by only one conventional strain gage if the principal axes are known,

and if the gage is mounted at a specific angle, Fig. 6. Thus the gage is affected by both principal strains in the correct proportion. The proportion is independent of the ratio of principal strains and is determined entirely by Poisson's ratio. The offset angle ϕ equals $\tan^{-1}\sqrt{\mu}$ and is the same angle used in the chevron grid. Here the strain is measured along the gage axis and multiplied by a constant K, a special biaxial modulus of elasticity, ($K = E/(1 - \mu)$. For a particular material, therefore, the gage-mounting angle is always constant.

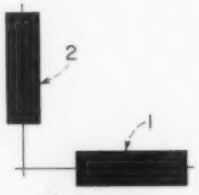
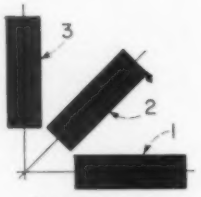
If both principal stresses are desired, two strain gages are employed, mounted at the angle ϕ away from each principal axis. The maximum shear stress cannot be obtained from the measured normal stress because the shear stresses are zero only on the principal planes.

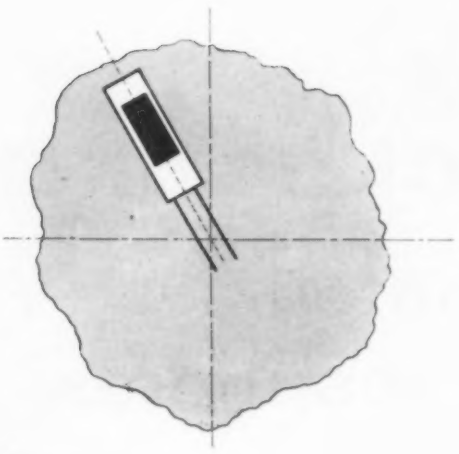
Single-gage techniques are popular because the gages are available in a wide range of type and size. Rosettes are quite large, therefore subject to error when applied in a zone of steep stress gradient. Individual strain gages, in contrast, have gage lengths as short as $\frac{1}{32}$ in.



5 Grid configuration . . . of a typical commercial stress gage.

TABLE 1 – RELATIONS BETWEEN

Rosette types / Required solution	Two-gage 	Rectangular 
Max normal stress, σ_{max}	$\frac{E}{1-\mu^2}\left(\epsilon_1 + \mu\epsilon_2\right)$	$\frac{E}{2}\left[\frac{\epsilon_1+\epsilon_3}{1-\mu} + \frac{1}{1+\mu}\sqrt{(\epsilon_1-\epsilon_3)^2+\left[2\epsilon_2-(\epsilon_1+\epsilon_3)\right]^2}\right]$
Min normal stress, σ_{min}	$\frac{E}{1-\mu^2}\left(\epsilon_2 + \mu\epsilon_1\right)$	$\frac{E}{2}\left[\frac{\epsilon_1+\epsilon_3}{1-\mu} - \frac{1}{1+\mu}\sqrt{(\epsilon_1-\epsilon_3)^2+\left[2\epsilon_2-(\epsilon_1+\epsilon_3)\right]^2}\right]$
Max shearing stress, τ_{max}	$\frac{E}{2(1+\mu)}\left(\epsilon_1-\epsilon_2\right)$	$\frac{E}{2(1+\mu)}\sqrt{(\epsilon_1-\epsilon_3)^2+\left[2\epsilon_2-(\epsilon_1+\epsilon_3)\right]^2}$
Angle from gage 1 axis to max normal stress axis, φ_p	0	$\frac{1}{2}\tan^{-1}\left[\frac{2\epsilon_2-(\epsilon_1+\epsilon_3)}{\epsilon_1-\epsilon_3}\right]$



6 Single gage . . .
mounted at an angle directly measures principle stress.

and produce more precise results. Individual gages also offer a much wider choice of strain-sensitive wire, grid and lead arrangements, and gage-backing material than the rosettes. More important, they are more applicable to the study of dynamic stresses. To obtain the instantaneous magnitudes of the principal stress from the oscillographic records of two or three individual gages in a rosette is a prodigious exercise in data reduction. The single-gage technique will perform all mathematical operations continuously and automatically to provide a running record of the dynamic variations in principal stress magnitude.

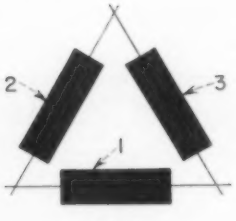
EDITOR'S NOTE: Other phases of stress analysis have been covered in:

"Three-Dimensional Photoelasticity," July '57, 135, describing materials, equipment and methods for analysis of complex parts.

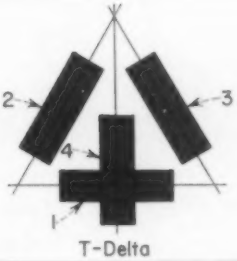
"Photostress," Sept '57, p 167. A new photoelastic technique for observing and measuring surface strains.

"Predicting Elastic Failures," March '56, p 178.

STRAIN ROSETTE READINGS AND PRINCIPAL STRESSES



Delta



T-Delta

$$E\left[\frac{\epsilon_1+\epsilon_2+\epsilon_3}{3(1-\mu)} - \frac{1}{1+\mu}\sqrt{\left(\epsilon_1-\frac{\epsilon_1+\epsilon_2+\epsilon_3}{3}\right)^2+\left(\frac{\epsilon_2-\epsilon_3}{\sqrt{3}}\right)^2}\right]$$

$$\frac{E}{2}\left[\frac{\epsilon_1-\epsilon_4}{1-\mu} + \frac{1}{1+\mu}\sqrt{(\epsilon_1-\epsilon_4)^2+\frac{4}{3}(\epsilon_2-\epsilon_3)^2}\right]$$

$$E\left[\frac{\epsilon_1+\epsilon_2+\epsilon_3}{3(1-\mu)} + \frac{1}{1+\mu}\sqrt{\left(\epsilon_1-\frac{\epsilon_1+\epsilon_2+\epsilon_3}{3}\right)^2+\left(\frac{\epsilon_2-\epsilon_3}{\sqrt{3}}\right)^2}\right]$$

$$\frac{E}{2}\left[\frac{\epsilon_1-\epsilon_4}{1-\mu} - \frac{1}{1+\mu}\sqrt{(\epsilon_1-\epsilon_4)^2+\frac{4}{3}(\epsilon_2-\epsilon_3)^2}\right]$$

$$\frac{E}{1+\mu}\sqrt{\left(\epsilon_1-\frac{\epsilon_1+\epsilon_2+\epsilon_3}{3}\right)^2+\left(\frac{\epsilon_2-\epsilon_3}{\sqrt{3}}\right)^2}$$

$$\frac{E}{2(1+\mu)}\sqrt{(\epsilon_1-\epsilon_4)^2+\frac{4}{3}(\epsilon_2-\epsilon_3)^2}$$

$$\frac{1}{2}\tan^{-1}\left[\frac{\frac{1}{\sqrt{3}}(\epsilon_2-\epsilon_3)}{\epsilon_1-\frac{\epsilon_1+\epsilon_2+\epsilon_3}{3}}\right]$$

$$\frac{1}{2}\tan^{-1}\left(\frac{2(\epsilon_2-\epsilon_3)}{\sqrt{3}(\epsilon_1-\epsilon_4)}\right)$$

how to select
MOTOR ENCLOSURES
for contaminated atmospheres

CHARLES C. LIBBY, MANAGER

Electrical Dept., Fairbanks, Morse & Co. Fairlawn, N. J.

Contaminated air and insufficient cooling can be unhealthy for motors and lead to shorter life for windings and bearings. Motor enclosures evaluated here will solve most of these problems.

Ambient Conditions Requiring Special Enclosures

CONTAMINANTS that attack motor insulation or inhibit ventilation:

- **Gases or vapors** – water vapor, corrosive gases, chemicals or solvent vapors
- **Dry particles or dust** – abrasive, conducting, magnetic, corrosive, clinging or fibrous
- **Liquids, droplets or mist** – water, rain, sleet or snow, dripping or splashing; steam or hot water under pressure; corrosive liquids; solvents; lubricants

OPERATING HAZARDS dangerous to operators or plant:

- **Explosive or inflammable gases or dust**

OPERATING CONDITIONS that reduce life of motor winding:

- **High humidity** – excessive moisture or steam; longtime shutdowns under moderate or varying humidity
- **Outdoor exposure** – direct sunlight; wind-driven rain, sleet or snow
- **Standby service** – operated less than once a month in a humid or outdoor installation
- **Altitudes over 3300 ft.**
- **Limited ventilation** – partial enclosure of motor in driven machine; small or unventilated installation space; dust, dirt or clinging dust partially covering motor or blocking ventilation

Degree of Protection Provided by Enclosures

MINIMUM – no protection from airborne particles, droplets or gases; space heaters for standby; special insulation for high humidity

- General-purpose, open
- Drip-proof
- Splash-proof
- Guarded or screened-frame (against rodents or mechanical injury)
- Open, lint-free

WEATHER PROTECTED – baffles remove dripping and splashing water, rain, snow, sleet; space heaters for standby

COMPLETE PROTECTION – under 200 hp; totally enclosed nonventilated or fan-cooled to keep out particles or droplets, but not gases; space heaters or special insulation plus drains for standby or high humidity

- General purpose
- Dust-explosion-proof
- Explosion-proof (resists internal explosion)
- Chemical
- Lint-free

ENCLOSED VENTILATED – space heaters for standby

- Self-ventilated from source of clean, dry air
- Force-ventilated with external source of air or with heat exchanger

If ambient atmospheres for industrial motors were always clean, cool and dry, standard open motors could be used. But when conditions are not that ideal, the motor selected must have a suitable enclosure. This is not a problem of duty cycle, which has been discussed at length in earlier articles, but rather the means used for motor cooling.

Dust and lint, corrosive fumes, moisture and splashing water—these are contaminants in the ordinary sense. But life of the motor windings can also be shortened by operation in high altitudes or humid atmospheres, by outdoor service or long periods of idleness. There are also special situations; for example, in the presence of inflammable or explosive dust or gases, the enclosure must protect equipment and operator if the motor fails.

Any one of the contaminants, hazards or ambient conditions listed in the first table on page calls for a special enclosure, a special protective design, or both—instead of a general-purpose, open-type motor. The protection given by various types of enclosures is shown in the second table, listed in the order of increasing protection.

• **It is possible to overprotect the motor.** But for lowest cost, enclosure should match only the amount of protection needed. Moreover, compared with enclosed motors, those with minimum protection have better ventilation, lower operating temperatures, and higher overload capacity.

• **When several contaminants are encountered,** select the enclosure for the severest condition.

• **Expect a reduction in motor life** if an enclosure is selected that offers less protection than recommended here.

Requirements or limitations arising from overload, unusual duty cycle, or abnormal mounting are additional factors, but not discussed here. Electrical and mechanical characteristics, rating, temperature rise, and torque characteristics have been considered in earlier articles (see Editor's Note at end of this article).

HAZARDOUS LOCATIONS

To protect operators, plant equipment, and buildings from fire or explosion caused by electric motors in hazardous or inflammable gases, vapors and dusts, the National Electric Code (published by National Board of Fire Underwriters) requires motors approved by independent Underwriters' Laboratories for locations with these atmospheric contaminants:

CLASS I

Group A—Acetylene
Group B—Hydrogen, or gases or vapors of equivalent hazard such as manufactured gas
Group C—Ethyl-ether vapors, ethylene, or cyclopropane
Group D—Gasoline, hexane, naphtha, benzine, butane, propane, alcohol, acetone, benzol, lacquer-solvent vapors, or natural gas

CLASS II

Group E—Metal dust, including aluminum, magnesium and their commercial alloys
Group F—Carbon black, coal or coke dust
Group G—Flour, starch or grain dusts

Motors approved for these locations carry a special label which states the Class and Group.

National Electrical Code requires explosion-proof squirrel-cage induction motors for Class I and dust-explosion-proof for Class II, whether the hazardous dust or gas is present continuously or intermittently, or during a breakdown that might cause failure of several motors. However, the code permits use of unapproved enclosed squirrel-cage induction motors in locations where a hazard may exist only as the result of an accident to tanks or hoppers of the hazardous liquids or dust, or to the ventilation or dust-control system.

Class III hazardous atmospheres containing airborne fibers, such as are found in a textile plant, do not require explosion-proof motors.

Motors as large as 1500 hp are available as totally enclosed, nonventilated and totally enclosed fan-cooled: designated as explosion-proof, and dust-explosion-proof (Class II). The Insurance Underwriters or other code-enforcing agencies call for motors specified by NEC in available sizes. The National Bureau of Fire Underwriters has issued separate standards and recommended safeguards on specific applications including centrifugal fire pumps, liquified petroleum gases, pulverized fuel systems, grain elevators, blower systems for vapor and dust removal, spray finishing, airplane hangers, and flammable liquids.

NEMA Standard MG 1-1.21 defines the explosion-proof machine as a "totally enclosed machine whose enclosure is designed and constructed to withstand an explosion of a specified gas or vapor which may occur within it, and to prevent ignition of the specified gas or vapor surrounding the machine by sparks, flashes or explosions of the specified gas or vapor which may occur within the machine casing." It also defines a dust-explosion-proof motor as a totally enclosed machine with enclosure so designed that a motor failure will not cause ignition or explosion of an ambient atmosphere of a specific dust. However, this type of enclosure is not successful where the motor is subject to overheating from overload, or where excessive quantities of dust can accumulate on the machine.

The explosion-proof motor is built to withstand an internal explosion without producing an external flame, whereas the dust-explosion-proof motor prohibits dust from entering the enclosure in sufficient quantity to cause an explosion.

CHEMICAL CORROSION

While not covered by nationally recognized standards, motors subject to corrosive fumes, mist or dust usually are totally enclosed nonventilated, or totally enclosed fan-cooled, in ratings up to 200 hp. Motors over 500 hp are often totally enclosed pipe-ventilated, with filtered air intake.

Generally designated as "chemical" motors, these types include features such as:

• Drain plugs or drain cocks for liquids that may condense in the enclosure.

(Next page, please)

- Stainless steel nameplates.
- Corrosion-resistant material such as cast iron or stainless steel for cast boxes or baffles.
- Stainless-steel or cadmium-plated steel external holding bolts.
- Stator laminations enclosed within the cast-iron motor frame, or covered with stainless steel or other chemically resistant material.
- Bronze, aluminum, wrought iron or plastic for external fans, depending upon the chemical exposure.
- Stator leads sealed in the frame to prevent entrance of contaminant through the conduit box.
- Exterior paint to resist corrosion or abrasion.
- Special insulation.
- Space heaters.

Winding insulation for a chemical motor is usually specified as "special Class A" or its equivalent, involving additional dips and bakes of protective varnish. Some applications may require Class-H or Class-B high-temperature insulation, or silicone treatment.

Chemical motors for explosive atmospheres must also meet NEC requirements for explosion-proof motors.

High-humidity service requires space heaters or automatic drain plugs. Space heaters are common for larger motors, but not for smaller motors unless they are periodically idle for two weeks or more at a time. Space heaters for explosion-proof motors must be installed at manufacture, and the leads sealed in the same manner as the motor leads.

MAGNETIC DUST

Motors for equipment operating in atmospheres containing magnetic dust, such as from taconite ore, must be special types of totally enclosed, or totally enclosed fan-cooled in smaller sizes; in the larger sizes, enclosed separately ventilated enclosures are required. Special shaft seals keep metallic particles out of motor enclosures and bearings. Stator leads are sealed, and variations in atmospheric pressure are equalized through a filter.

METALWORKING MACHINES

Motors for machine-tool and other production equipment are usually totally enclosed nonventilated or totally enclosed fan-cooled. The Joint Industry Conference (JIC) Electrical Standards specify an enclosed design, with fan-cooled construction required for ratings from 5 hp to 50 hp at 1200 rpm, and fan cooling optional in the smaller enclosed sizes. Motors larger than 100 hp may use pipe-ventilated enclosures if a source of clean, cool air is available.

Machine Tool Electrical Standards do not specify the motor enclosure, but refer to NEC which requires explosion-proof or dust-explosion-proof motors in hazardous locations and atmospheres.

Enclosed fan-cooled motors protect from:

Abrasive dust dangerous to the bearings and windings. In an open motor, interior ventilating fans throw dust particles against the inside periphery of the stator coils where they protrude beyond the stator core. Abrasive action wears away the insulation.

Conducting dust, such as graphite. A conducting layer over the stator winding increases the likelihood of winding failure.

Solvents, such as lubricating oils or greases. Lubricants that leak into the winding, or are forced out of bearings by improper lubrication, weaken insulation.

Metal particles, particularly iron or steel chips, carried into the motor as dust. Particles work their way through motor insulation, under action of the stator magnetic field, and cause premature failure.

OUTDOOR SERVICE

For equipment subject to outdoor weather, special Class A insulation is used with open motors to permit free flow of ambient air to the windings. Large baffles and drain spaces remove particles of rain, sleet or snow. These motors are not suitable for hazardous, flammable or explosive atmospheres, or for cooling air containing excessive particles, dust or vapor that would attack the insulation.

When subject to high winds carrying water, snow or dust, a special weather-protected enclosure can be obtained at considerably higher cost. While standard enclosed fan-cooled or splash-proof motors are sometimes used for outdoor service, weather-protected enclosures are better where moisture may condense within the motor, or where air passages may be clogged by ice or snow.

HIGH HUMIDITY

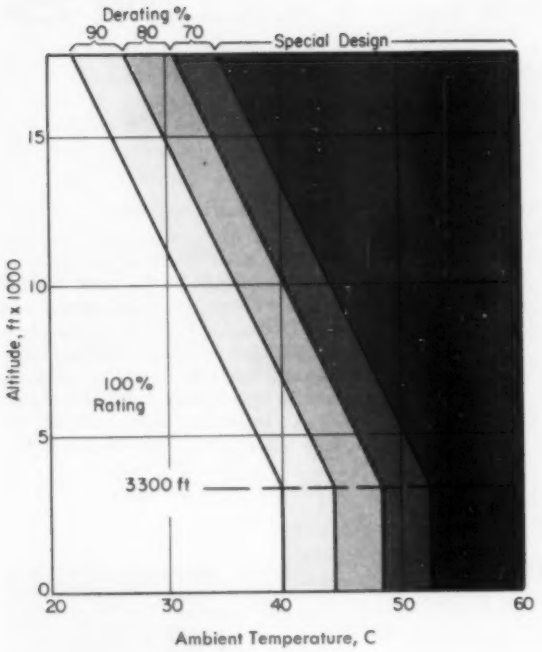
Authorities differ on the best combination of enclosures, baffles, insulation, or space heaters for motors installed in highly humid atmospheres. Major consideration is the proportion of time the motor is not operating. Where used only occasionally or seldom, a

Mounting, Too, Affects Enclosure

Design modifications not related to contaminants are sometimes required, and may influence final selection of enclosure type. They include:

- Vertical operation of horizontal motors such as wall mounting in restricted space.
- Thrust imposed on motor shaft by a direct-mounted load.
- Special dynamic balance requirements for precision-tool applications.
- Reduced end play for direct-mounted close-clearance load.
- Torsional vibration or shock, such as direct-connected chipper hammermill or textile mill.
- Vibrations or shock in mounting surface, as in a railroad car.
- Ambient or explosive shock, as in combat operations.

These may require special tests and bearings; and for torsional shock, special rotors and rotor fans. For example, motors to meet Navy service A require a special motor with nodular cast iron or cast steel instead of cast iron in structural parts.



Dissipation of heat . . .

in fan-cooled motors is influenced by air density at altitudes above 3300 ft; higher altitudes require appreciable motor de-rating. Altitude has little effect on totally enclosed motors because most of the heat is removed by radiation.

drip-proof, splash-proof, weather-protected or an open, pipe-ventilated motor with special moisture-resisting insulation will operate satisfactorily. Moisture accumulating in the motor while not running is evaporated by motor heat and blown out during operation. If an enclosed motor is necessary for other reasons, it must be modified to prevent accumulation of condensate.

Two modifications for nonhazardous applications are: keep the motor warm by space heaters or by application of a low-voltage single-phase current to the windings; or use drains and special Class A moisture-resisting insulation in the stator winding. Drains may be open weep holes, removable plugs, spigots, or automatic plugs. In explosion-proof motors, the same alternate modifications are effective, but drain plugs must be UL-approved, and built into the motor.

LINT

When the atmosphere is filled with fine floating fibers, as in textile mills, special motor construction is necessary to keep ventilating passages from clogging in standard open or enclosed fan-cooled motors. Or totally enclosed nonventilated motors may be used.

Lint-free motors have stator windings and rotors, fans, ventilating passages and other motor openings treated to eliminate lint-catching projections or burrs. NEC in Section 5076 permits a lint-free motor for machines used in Class III hazardous locations such as textile, garment and woodworking plants, provided lint accumulation is moderate and the motor is readily accessible for cleaning.

FOOD MACHINERY

Atmospheres containing flour, grain or starch dust require a dust-explosion-proof motor, Class II, Group G. When processes require sterilization or special sanitary cleaning—as in dairies, bottling plants or ice cream processing plants—special "sanitary motors" feature smoothly rounded surfaces, and elimination of openings or recesses that might accumulate unhygienic deposits. The design includes a corrosion-resisting shaft, external parts made of stainless or corrosion-protected steel, and special frame paint.

HIGH-ALTITUDE OPERATION

Lower density and heat capacity of air at higher altitudes reduces the cooling effectiveness and raises motor temperature. An open motor is less affected than an enclosed motor. Under NEMA standards, normal rating for open or enclosed construction applies to altitudes from sea level to 3300 ft. Standard motors rated 50-C or 55-C rise with 1.0 service factor and Class A insulation (such as enclosed, splash-proof or short-time-duty motors) are not suitable for operation over 3300 ft. Standard open or open drip-proof motors with Class A insulation, 1.15 service factor and a 40-C rise will develop a temperature rise of 50 C at altitudes between 3300 and 9900 ft.

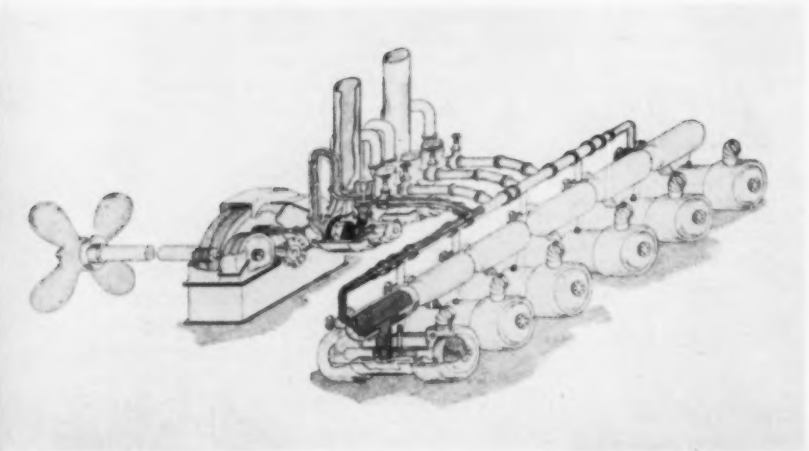
Totally enclosed 50-C rise, fan-cooled motors for splash-proof or intermittent duty will not have normal life expectancy above 3300 ft. Higher-cost motors with larger frames and special design, or Class B insulation must be used for higher altitudes.

Between 3300 and 9900-ft altitudes, standard motors with 40-C rise and service factor rating of 1.15 or higher are derated to a service factor of 1.0 with no temperature-rise guarantee.

At altitudes over 9900 ft, special motors are required, either with standard insulation and larger size frames, or with special Class B or Class H insulation. Both increase the cost.

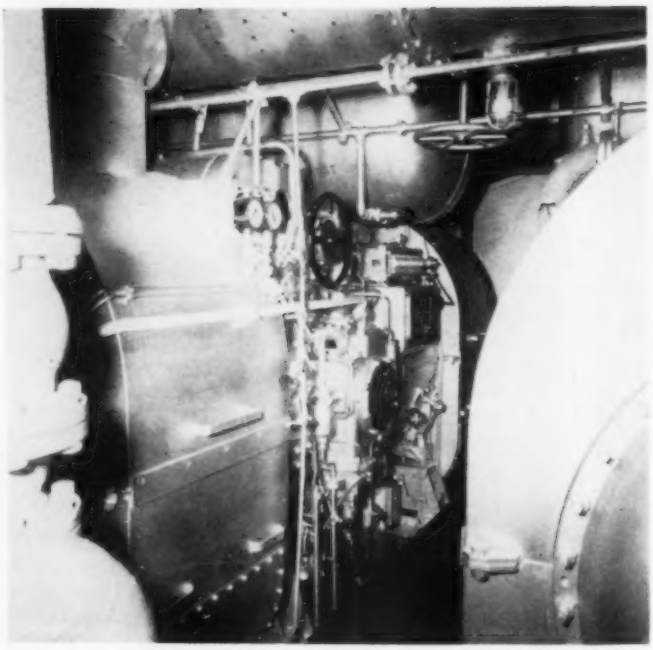
EDITOR'S NOTE: Temperatures and contaminants work together to reduce motor life. Overheating problems during startup can sometimes be avoided by selecting lower base-speed motors, as explained in "Lower-Speed Motors for High-Performance Drives," Sept 16 '57, p 96. "Controlling Temperature Rise in Squirrel-cage Induction-Motor Drives," Jan '57, p 167, elaborates on winding temperatures and motor life, showing how to calculate the rise and to reduce motor heat; it discusses duty cycles, ventilation, and NEMA standards relating to the problem. How variations in air density and temperature affect heat transfer in motor cooling is detailed in "Fan Cooling—Influence of Altitude," June '56, p 198. Factors involved in sealing motor and heater leads against contaminated atmospheres are treated in "Selection Data for Hermetically Sealed Terminals," June '54, p 178.

TECHNICAL NEWS



◀ **Six free-piston gasifiers . . .**
. . . line up from starboard to port and exhaust hot gases to turbines geared down to propeller shaft of the GTS William Patterson. Control of speed, Ahead and Astern is through hydraulic system from operating console to main control valve, in the gas line, that directs hot gases to Ahead or Astern turbine. Above the gasifiers are exhaust pots that collect gas for turbine intake.

Operating side . . . ▶
. . . is at front of gasifier on the Patterson (view here is from scavenge end toward exhaust end). Black hand-wheel starts engine by directing high-pressure air into the bounce chambers. Pistons are pushed toward inner dead point with enough energy to cause first firing. In another position, hand-wheel sends air to a small air piston that blocks the fuel pump, stopping the engine. Large perforated line overhead is air intake.



FREE-PISTON:

Old Hull, New Engine—Ship Hits 17 Knots

NEW YORK—Unrecognizable as a Liberty Ship, which in World War II had top speed of only 10 knots, the William Patterson is now a GTS (gas turbine ship) that has successfully passed official trials with speed of over 17 knots. Her triple-expansion steam reciprocating engine of 2500 hp was replaced by a free-piston gas turbine power plant of 6000 shaft hp. Also new is a streamlined bow section.

She is fourth and last unit of the Maritime Administration's Liberty Ship Conversion and Engine Improvement Program. Other three converted in the $12 million project (Nov. '56, p. 214):

SS Benjamin Chew—a minimum conversion (no bow change) but 2500 shaft hp engine replaced by 6000 shaft hp steam turbine. Existing boilers and pumps were retained.

SS Thomas Nelson—the first conversion to lengthen and modify bow section. Original propulsion unit replaced by two 3000 shaft hp diesel engines with fuel-treatment equipment to permit use of cheaper Bunker C fuel. Movable cranes replaced conventional cargo equipment.

GTS John Sergeant—world's first large merchant ship powered solely by an open-cycle gas turbine. This ship has controllable-pitch propeller and new bow section.

The six free-piston gasifiers on the William Patterson were assembled by

the Cleveland Diesel Engine Div. of General Motors from parts made by GM and parts bought from SIGMA of France (Societe Industrielle Generale de Mechanique Appliquee), with whom GM now has a licensing agreement for manufacturing these engines. The vessel's engines are combined with two Alathom reversible gas turbines of 3000 shaft hp, also of French make. The two turbine shafts connect to the propeller shaft through double reduction gears.

HOW IT WORKS

Free-piston engines for marine use operate on the two-stroke diesel cycle and use Bunker C oil for fuel after starting with diesel oil. Each gasifier has two opposed pistons in a single power cylinder. Combustion occurs in the cylinder, and power is produced by exhaust gases at moderate pressure (about 45 psi) and temperature (800 to 900 F). This power drives the gas turbines. On opposite ends of the power pistons are two larger pistons operating in two air cylinders that act as bounce chambers. They force the power pistons back to compression stroke, where fuel is injected for the next combustion stroke. With few critical materials needed because of its low operating temperature and pressure, the engine is thought to have potential in mobilization planning.

The converted vessel's free-piston engine is noisier than its former propulsion equipment, and two diesel generator units add to the din. The entire plant is shoe-horned into a place once occupied by two boilers, a 2500-hp engine and small auxiliaries. A government lab representative believes noise and vibration can be significantly reduced by using a plenum chamber in the air inlet. There would be far less noise, in a ship designed specifically for free-piston-type propulsion.

Each gasifier delivers 1233 gas hp at a thermal efficiency of 41%, and the over-all turbine efficiency is 85%. This high efficiency is making manufacturers of steam-turbine marine and stationary power plants think hard about free-piston engines. The French already have units in many small coastal vessels, and orders for about 300 more. A free-piston engine manufacturer reportedly took a contract for a Philippine power plant from a large US steam turbine manufacturer. Many European countries as well as GM here, have been licensed by SIGMA to produce the engine.

FUEL COSTS ARE LOWER

At one time, manufacturers of steam powerplants enjoyed comparing their low-cost Bunker C fuel with the more expensive fuel used in internal combustion engines. Now, this cost benefit is eliminated, and comparison pivots on efficiency of operation (which favors the free-piston installation) and maintenance costs, (which free-piston manufacturers say will be low, but which steam advocates deem will be high). A year's operation by the Military Sea Transport Service will tell.

On the trial run in New York Bay, there was an impressive list of visitors from many industries other than marine, because of the serious consideration being given to the free-piston idea as a new means of propulsion. The idea is not new, of course; free-piston air compressors were built in France by R. Pescara in 1923, and some were used on German submarines in World War II.

Unique Grad School Is Thriving

HARTFORD, CONN.—The first accredited graduate school of engineering born of a community's technical-manpower needs last month celebrated its second birthday.

In 1954 United Aircraft Corp. approached Rensselaer Polytechnic Institute with the idea of setting up a graduate engineering center in the Hartford area. United was motivated by the engineering shortage and a desire to provide its technical staff with educational facilities not available locally.

RPI officials agreed to staff the school and conduct an academic program in keeping with standards maintained at their Troy, N. Y. campus. United agreed to supply all the land, buildings, equipment and money.

A former suburban shopping center was purchased, and within a few months transformed into a modern, one-story buildings with classrooms, seminar rooms, technical library, administrative offices, auditorium and cafeteria. Cost to UA: $625,000 including $10,000 worth of library books. All was deeded to RPI.

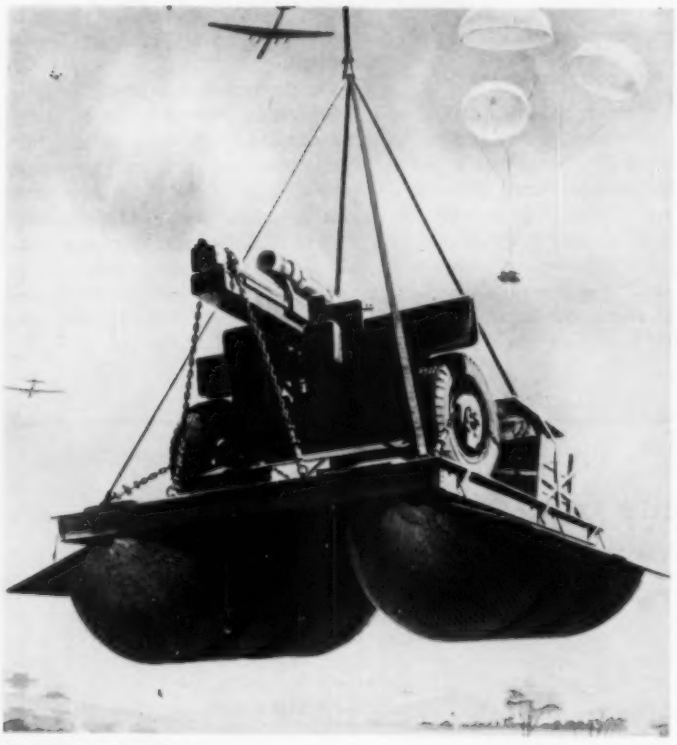
When the call for support went out —for prospective students and financial aid—response of companies in this heavily industrialized area was enthusiastic. By fall of 1955, some 210 area-employed engineers enrolled for 900 credit hours.

Today, the center boasts a faculty of 40, an enrollment of 450 working engineers, and an academic schedule offering MS degrees in 10 major fields. Student age ranges from 21 to 50. About 99% have scholarships provided by their employers. Though tuition charge is $65 per credit-hour, and some 2,100 credit hours are being offered, this revenue doesn't meet operating costs. Outright gifts from local companies make up the rest.

On the faculty are 12 resident professors from RPI. They are assisted by 25 "adjunct" professors, scientists and engineers from local companies, who teach one course a semester. The Dean and director of the center is Dr. Warren C. Stoker, associate director of RPI's Graduate Division and former director of its computer laboratory. Administrative manager is Harry O. Bartlett, local businessman.

Classes are scheduled from 3:45 pm through the evening hours. Students may work for MS degrees in aeronautical engineering, applied mechanics, and/or data processing, mechanics, metallurgy, mechanical engineering, management, automatic control, electrical engineering, nuclear science and nuclear engineering. To some extent, courses a student takes are guided by his company's needs.

Most students attend two classes a week and can complete the 30 credit-hours required for an MS in five semesters, or 30 months. Admission is not restricted to engineers working for sponsoring companies. Ten other area companies are participating in the program along with United. The center also offers its services to industry on a consultation basis, with the research facilities of the campus at Troy available for technical assistance.



Paper honeycomb . . .
becomes expanded shock absorber in artist's conception of Northrop's design for airdropping bigger military-equipment loads at faster descent rate.

Faster, Safer With Honeycomb Cushion

LOS ANGELES—A radially expanded paper honeycomb, shaped much like a paper Christmas bell and attached as a cushion to a metal raft carrying heavy military equipment, has been designed by Northrop Aviation to answer the need for more efficient combat airdrops.

Still to be field tested, the design is intended as a safe means of dropping complete assault-equipment packages at rapid descent rates, in contrast with results obtained using the present air-bag method. The honeycomb is flat at loading time and expands to arc shape in mid-air.

Devised by the Aero-Mechanical Projects Dept. of Northrop's Radioplane Div., this cushion would serve as a true impact-absorbing structure—impact energy would collapse the paper cells. Indications are the honeycomb can decelerate a cargo with drop speed of 35 to 50 fps without exceeding the 10-G max deceleration limit required by the military. Air bags are limited to drop speeds of 20 fps.

Material for the shock absorbers is standard 60 to 100-lb per ream kraft paper which is assembled much like a closed book. Mechanical release permits this honeycomb to reach a pre-expanded position with parachute harness tension allowing the paper to open fully. Three 64-ft chutes on a 750-lb "raft" will drop 11,759 lb at 40 fps. Chute is cut loose on ground by squib-firing inertial device.

Logistics experts have long sought a way to increase load size so complete combat packages can be dropped—time spent assembling a 105mm howitzer, for example, can cause failure of a combat mission. Load size is limited by cargo-chute capacity. Excessive load results in a too-rapid descent and subsequent damage; slow descent means dispersal of equipment, and vulnerability to enemy attack.

The honeycomb is also expected to save money for the government. Cost average of an airbag is $300, and each bag has a life expectancy of 10 drops—a cost figure of $30 per bag per jump.

Radioplane engineers point out also that airbags have an inherent high modulus of elasticity. Rebound force is usually directed to one side of the gravitational center, resulting in bounce and subsequent damage. With honeycomb structures, the load on impact "sticks like glue" in most cases regardless of the impact angle.

Smaller Engines–Bigger Production Problem

HARTFORD, CONN.—Manufacturing engineers at GE's River Works find that production problems increase with decrease in size of their T58 jet engine. It weighs 250 lb, delivers 1050 hp—compared with 2520-lb weight and 5820 thrust of its "big brother", the J47. L. W. Wait of the Mfg. Engrg. Dept. of GE made this comment at ASME's recent meeting.

Parts that required thousandths of an in. tolerance in the J47 now demand a tolerance of 0.0001 in. Many of the parts are being precision-machined for weight-control only. Aluminum and magnesium castings have been nearly eliminated and are being replaced by thin, lightweight fabrications. Metal-arc welding cannot be used on the small jet—the 3/32-in. bead (smallest that can be applied practically) is three to four times the thickness of the parent material. Inert arc-welding or high-temperature brazing is the replacement. Low chrome-moly, A286, and type 410 steels are in use. Wall thicknesses are 0.020 to 0.040 in.

Tolerance on thickness can be as close as ±0.0005. Compressor-blade airfoil contours are held to ±0.0015 of true shape; this compares with ±0.0045 allowable for J47 blades. Large compressor blades are precision forged, but this method is impractical for very thin airfoil tolerances (edges down to 0.007). The T58 blades are being machined from solid material with a 6-spindle Cincinnati Hydrotel.

Engineering 'South of the Border'

The engineer in countries below the Rio Grande is generally a man of considerable prestige avidly wooed by industry. In most Latin American countries the rapid rate of industrial development has outstripped capacity to train the number of engineeers required in new specialties. This has led to both retraining and foreign recruitment. Here's how the situation shapes up, according to on-the-spot reports from McGraw-Hill correspondents:

RIO DE JANEIRO—Brazil's recruiters call the shortage of mechanical engineers "incredible." But industry is dipping into the oversupply of civil engineers and architects, and retraining them to keep up with the industrial boom here. Ordinary draftsmen are being converted to full-time engineers when they show talent.

Engineers are also coming from abroad—many from the mid-East and Eastern Europe. Some work out the foreign-company contract that brought them, then move into a local Brazilian venture. One big electrical equipment company in Rio has only two Brazilian-born engineers among the 20 technical section chiefs.

A local law requires two-thirds of a company's employes to be native-born. Companies with many factory employes are not hindered, therefore, from using foreign engineers. Of those professional men not native-born, mechanical engineers can get local registration most easily.

Almost all mechanical engineers here are working on plant expansion, cost-cutting programs, and new product design. Only a very few are in research because Brazilian industry does not have the time or ready cash for research projects. Companies usually buy know-how on a licensing arrangement, or get it wholesale by merging with an American or European company for local production. This is expensive, but industrial plants find they have to spread out fast to keep up with developments.

People with inadequate backgrounds are daily being pushed into engineering jobs. This too, is costly, but Brazilians say it's better than nothing, and continue to expand. In an effort to tackle this problem, a Brazilian affiliate of American Can Co trains high-school graduates. Though these boys must still take college training to become registered mechanical engineers, they do well at jobs that an engineer would handle in most American or European factories.

The average product designer gets about $400 a month; talented designers get $650. When a company pirates a good man, sometimes by doubling what he was getting, it has him supervise a large group and pass along his know-how.

To be an engineer in Brazil is to be a designer and builder of big buildings, roads and dams. Engineers rank above lawyers and doctors. So, the engineering courses of all the universities are generally designed to turn out big builders and architects. There is a slight prejudice towards mechanical engineers, sometimes thought of as grease monkeys or common mechanics. Hence, the shortage in this group. However, demand has been so great that universities are adding more mechanical engineering courses, and college enrollments are on the upswing.

Brazil will feel the squeeze when its budding automobile industry gets going. Right now, G. M., Ford, Willys, Mercedes-Benz, Volkeswagen, D. K. W.-Vermag, Fabrica Nacional de Motores, Land Rover, and various parts-makers are planning to turn out 150,000 vehicles yearly, with 95% Brazilian-made parts, by 1960-61. Ford has just announced it is bringing 25 mechanical engineers and their families. Signs that Brazil is preparing to get into the aircraft business point to additional manpower problems.

BUENOS AIRES—Plenty of engineering graduates come out of universities here each year, but industry still complains of a shortage of trained men. The chief of a large company's industrial engineering department knows the reason: "Argentina graduates are very theoretical and lack practical experience. What makes matters worse is, many of them do not want this experience. They think it a disgrace to go into a workshop. They want to be executives right away. The majority look for desk jobs immediately. The engineering diploma has prestige, but there's a feeling that once the title is gained, you've made it and don't have to work any more."

This company and a number of other American affiliates send promising engineers to the home plant in the US for additional training. The great majority of successful and outstanding engineers working in Argentina have had some training abroad.

Big companies here, as in Brazil, are starting training programs to develop a good supply of engineers. Civil engineering graduates are abundant. The shortage is in mechanical, electrical, industrial, chemical engineers, and above all, in research personnel.

In the universities, there is a shortage of buildings, labs and equipment. Industry men are critical of college facilities and salaries. They feel the situation will get worse before it improves. On June 30, 1957, an Argentine-US technical corporation agreement was signed. Its effects on engineering training here will not be felt for some time.

Basic salary for an engineering graduate is now about $167 a month, but engineering associations are trying to raise this to $256, to avoid discouraging men from entering the profession. Average engineer's salary is about $278 a month. One automobile company pays its product engineers $389 and has been charged with large-scale pirating—the only such situation known in this country.

Only one applicant in 50 is qualified for design work here, according to one source. Specialists are often brought in from abroad.

MEXICO CITY—For every engineering graduate there are four positions available. The total number of engineers registered in Mexico is 8731. Of this number only 1254 are mechanical and electrical, 292 are metallurgists. Chemical engineers, 4641, lead the list; civil engineers, 2080, are second.

It is generally agreed that no indus-

try in Mexico has enough engineers. Because they offer higher salaries, the large companies are in a better position to tap available supply. They have fourth- and fifth-year students working for them. After graduation they're expected to work full-time.

Because of the engineering shortages here, people with inadequate training find their way into research and production departments. These jobs are often filled by men with no more than on-the-job training in a particular industry. As a result, little "original" research is being carried out —most firms import their development ideas from abroad.

Men trained as mechanical-electrical engineers are in shortest supply. Also in great demand are electronics engineers.

Solutions? Some firms, to ease immediate needs, pirate trained personnel from other firms—though this is theoretically frowned on. Companies employing two or three engineers pirate more often than large companies.

Some American firms here query engineering schools in the U. S. for names of Mexican or any Spanish-speaking students. These are asked to join the company after they graduate.

College enrollments in Mexico are rising, but some schools fear this even while recognizing the need for more trained men. Enrollments already are pushing against the limitations of physical facilities, such as labs. Qualified teachers are also needed.

Some students have won grants-in-aid to study in the U. S. or other countries. The Instituto Mexicano-Americano de Relaciones Culturales, in combination with the Bank of Mexico, is offering scholarships for students to study in the U. S.

Few Mexican companies can afford to pay the salaries that attract foreign engineers. Salary of a Mexican design or product engineer averages around $200 a month. Graduate engineers earn from $340 to $640 a month. A few companies, however, employ foreign engineers for special jobs.

Sight-and-sound Recorder Offered Abroad

ROME—Italy has come out with an unusual visual-phonograph recorder that resembles an ordinary record-player. Displayed recently at the Electronic Exhibition here, it reportedly can capture both visual and auditory signals on a matrix from which a large number of records can be produced. The programs are seen and heard on an ordinary TV set with the help of a special turntable that has been equipped with photoelectric cells.

Designed by Italian inventor Antonio Rubbiani, the machine produces records with playing time of 10 min, and dia from 35 to 45 cm. Highest recordable frequency is 7 megacycles. This recorder replaces the usual pickup with a thin "brush" of light and highly sensitized photoelectric cell. A transparent glass-fiber record, 40 cm dia, to which a film has been applied, revolves beneath the photoelectric cell. Images on the film appear on the screen of the TV set.

Ford Combats Knock With Shock

DETROIT—The piston knock in your automobile and the attending loss of power may become a thing of the past as the result of a study conducted by Ford Motor's Scientific Lab with a shock tube—the device producing fuel-air explosions that can be photographed.

Piston knock is caused by uncontrolled explosion of fuel-air pockets in a combustion chamber. Indications now are that future car-engine design may require fuel to be ignited at just the right instant, and burn at exactly the right rate to deliver maximum power.

To touch off the explosion, Ford scientists create supersonic shock waves in a tub 25 ft long with a 2 x 3-in. section, abandoning use of the familiar spark plug. Shock waves are produced by sudden release of compression helium gas, and travel through the tube at double and triple the speed of sound. A controlled explosion occurs when the waves strike a fuel-air mixture.

Ford scientists then study photos of the explosion, filmed at 15-millionths of a second, to get comparisons with uncontrolled explosions that will point the way to control them.

COMING EVENTS

OCTOBER

16 . . . . Society of the Plastics Industry, Cellular Plastics Division, Commodore Hotel, NYC.

16-18 . . . . American Society for Quality Control, 11th annual conference, Stratfield Hotel, Bridgeport, Conn.

17 . . . . Society of Plastics Engineers, regional technical conference, Hotel Carter, Cleveland, Ohio.

17-18 . . . . National Conference on Industrial Hydraulics, sponsored by Armour Research Foundation and Illinois Institute of Technology, Hotel Sherman, Chicago.

17-18 . . . . Magnesium Association, annual convention, Biltmore Hotel, NYC.

21-23 . . . . ASME National Power Conference, Americus Hotel, Allentown, Pa.

22 . . . . Association of Consulting Chemists and Consulting Engineers, annual meeting, Belmont Plaza Hotel, NYC.

24-25 . . . . Computer Applications Symposium, sponsored by Armour Research Foundation at Morrison Hotel, Chicago, Ill.

24 . . . . Engineer's Council for Professional Development, 4th annual general assembly, Hotel Statler, NYC.

24-25 . . . . Engineering Institute on Effective Drafting sponsored by University of Wisconsin, Madison, Wisc.

24-25 . . . . Aviation Electric Equipment, 14th annual display sponsored by the Aircraft Electrical Society, Pan Pacific Auditorium, Los Angeles.

27-Nov. 1. . . . International Atom Week sponsored by Atomic Industrial Forum and American Nuclear Society. Conference programs include: 1957 Trade Fair of the Atomic Industry, Oct. 28-31, New York Coliseum; 4th annual atomic industry conference, Plaza and Waldorf-Astoria Hotels, Oct. 28-30; 2nd winter meeting American Nuclear Society, Henry Hudson Hotel and N. Y. Coliseum, Oct. 28-30.

28-30. . . . National Lubricating Grease Institute, 25th annual meeting. Edgewater Beach, Chicago.

28-30. . . . Aeronautical and Navigational Electronics, 4th annual East Coast conference sponsored by the Baltimore section of the Institute of Radio Engineers. Fifth Regiment Armory, Baltimore, Md.

Got a temperature control problem?

Fenwal

Tell you what a THERMOSWITCH® unit will do . . .

With Fenwal THERMOSWITCH® Units YOUR EQUIPMENT WILL...

- **Run at Faster Speeds** with increased output because of more precise temperature control. The inherent sensitivity of a Fenwal THERMOSWITCH unit is 1/10 of one degree Fahrenheit. Enjoy this competitive advantage!
- **Require Less Maintenance.** A Fenwal THERMOSWITCH unit has ten times as much resistance to vibration as ordinary thermostats. It has military ruggedness to resist shock to 100 G's. And it's tamper-proof!
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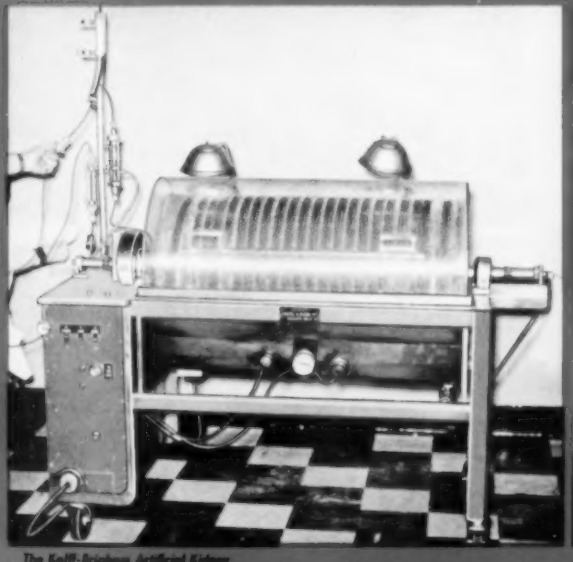
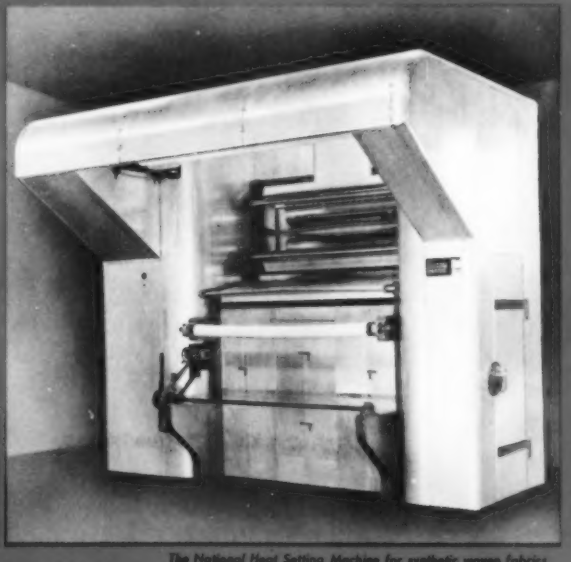
- **Have Longer Life.** Fenwal THERMOSWITCH units consistently provide one-half million or more cycles of precision temperature control. Cost is surprisingly low... not more than 2¢ per thousand cycles.
- **Have Reduced Assembly Costs.** All Fenwal THERMOSWITCH units fit a ⅝" hole, the cheapest machining operation. They're the same size as standard cartridge heaters!

for example...



The Kolff-Brigham Artificial Kidney



The National Heat Setting Machine for synthetic woven fabrics

From Delicate Medical Equipment to Rugged Production Machinery

Fenwal THERMOSWITCH units are being used in countless applications.

Here's why Fenwal THERMOSWITCH® units provide such advantages

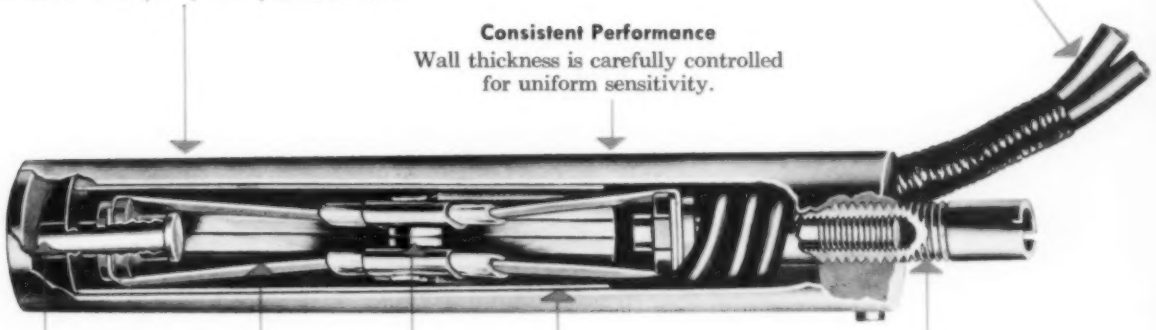
The activating control element is a single-metal shell that expands or contracts instantaneously with temperature change, making or breaking the totally-enclosed electrical contacts. The shell is the temperature-sensing element. There are no heat transfer paths as in ordinary thermostats.

SERIES 17000 BASIC DESIGN*

Maximum Dielectric Strength
Lead wires are Teflon-wrapped.

Easy Installation
All shells fit a 5/8″ (.0625″) reamed hole.

Consistent Performance
Wall thickness is carefully controlled for uniform sensitivity.



Shock and Vibration Resistant*
Struts are in tension or compression.

No Undershoot or Overshoot Problems*
Anchor pin has parting joint.

UL and CSA Listed*
Creep distances in accordance with standards of either group.

Field Adjustable
Simple — with a compound screw thread for fine adjustment.

Maximum Life and Control Accuracy
Specially designed fine silver contacts.

*TENSION TYPE ILLUSTRATED

Way ahead of ORDINARY THERMOSTATS
Only FENWAL THERMOSWITCH® units offer . . .

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- **Narrow Temperature Differential** — one-twelfth to one-eighteenth as great
- **Vibration Resistance** — one-tenth to one-eighteenth as much shock-sensitivity
- **Uniform Sensitivity** — throughout the operating range

Name your problem!

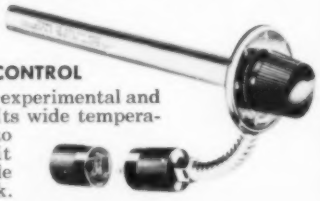
Chances are we can name a Fenwal THERMOSWITCH® unit to solve it!

There's a Fenwal sales engineer ready to apply one of 25000 THERMOSWITCH unit variations to your particular heat control problem. Here are just a few . . .

STANDARD TYPE

SERIES 17000
CARTRIDGE
THERMOSWITCH CONTROL
Easily inserted in reamed hole in metal blocks and other solids.

EXPERIMENTAL TYPE

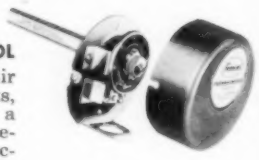


SERIES 17500
ALL-PURPOSE
THERMOSWITCH CONTROL
Generally used for experimental and laboratory work. Its wide temperature range (−100 to 600° F) makes it useful in a wide variety of test work.

FLUID IMMERSION TYPE

SERIES 17100
HEX HEAD
THERMOSWITCH CONTROL
Easily inserted directly into fluid by mounting in a tapped hole in container wall.

AIR CONTROL TYPE



SERIES 17700
JUNCTION BOX AIR
THERMOSWITCH CONTROL
Ideal for the control of air temperatures in air ducts, ovens, driers, etc., where a conduit junction box is required to facilitate electrical wiring. Available for fluid immersion also.

SURFACE MOUNTING TYPE

SERIES 17300
FLANGE HEAD
THERMOSWITCH CONTROL
The three tapped holes allow this unit to be mounted against any flat surface with proper size screws. A dial and knob as well as flexible lead wires can be attached.

CLOSED SYSTEM TYPE

SERIES 18000
COUPLING HEAD
THERMOSWITCH CONTROL
Generally used in closed liquid or gas systems by direct insertion in the medium to be controlled.

Write for a free booklet (MC-135) containing complete specifications on Fenwal THERMOSWITCH units.

Fenwal

INCORPORATED

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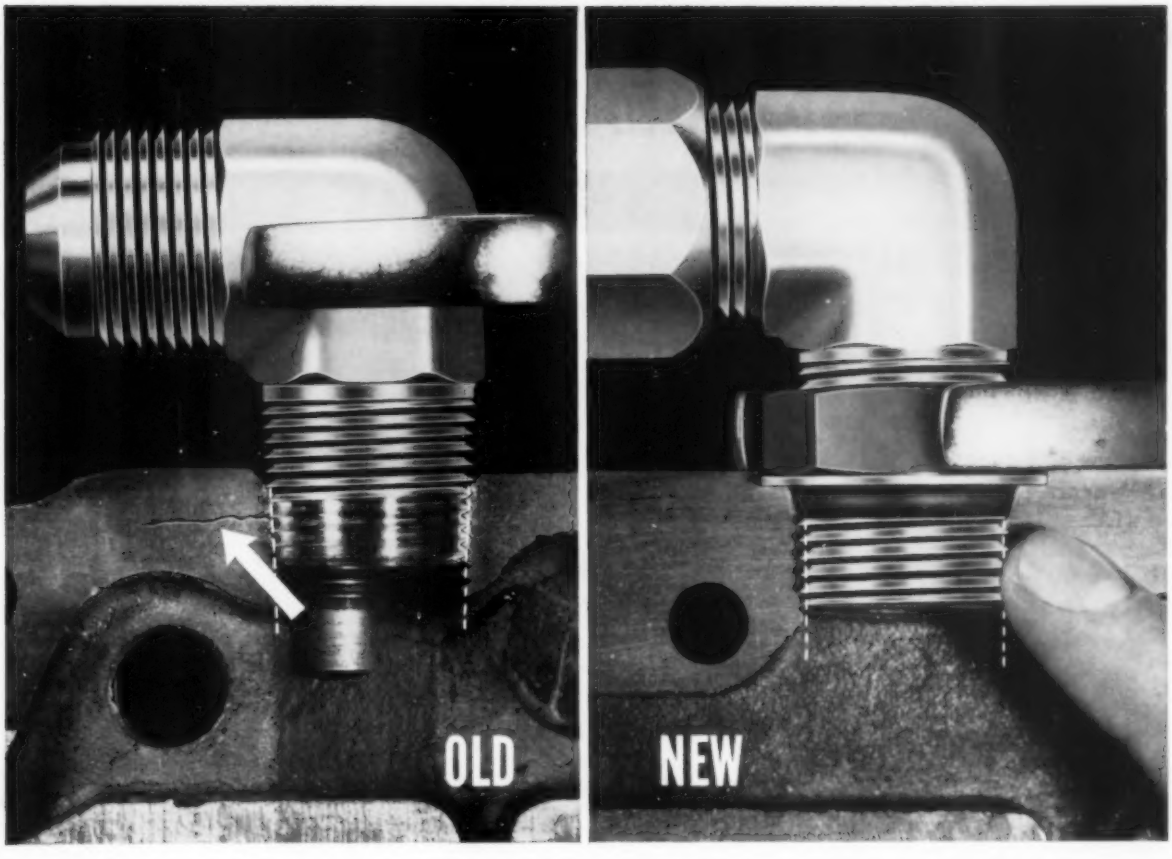
CONTROLS TEMPERATURE . . . PRECISELY



How Parker straight-thread fittings solve leakage problems

Forget about danger of cracking or distorting valve bodies by overtightening the fittings. Forget about messy pipe "dope." Forget about leakage problems resulting from tapered pipe threads in high-pressure hydraulic systems.

Eliminate these problems. Use Parker O-ring seal straight-thread fittings (which conform with the SAE Standard for Hydraulic Tube Fittings) for leakproof, trouble-free connections. Available on Parker *Triple-lok* (the industrial standard flare tube fitting) and on Parker *Ferulok* (flareless fitting for heavy steel tubing).

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Hydraulic and fluid system components

New, Broader Line of *Hoze-lok* fittings for medium- and high-pressure hydraulic service. Longer performance, greater re-usability. No skiving of hose. Easier make-up saves time and money.

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Section 436-CC
The Parker Appliance Company
17325 Euclid Ave.,
Cleveland 12, Ohio

Please send:

- ☐ *Triple-lok* Fitting Catalog 4310
- ☐ *Ferulok* Fitting Catalog 4320
- ☐ *No-Skive Hoze-lok* Catalogs 4433 & 4434

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6 Applications of Ultrasonic

They will:

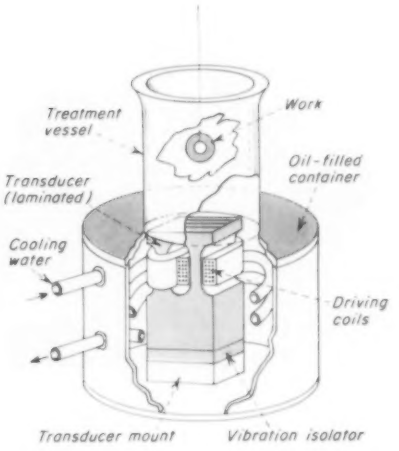
- **clean**
- **drill**
- **solder**
- **weld**
- **test and measure**

Certain materials undergo a reversible change when subjected to magnetic or electric fields, and thus can serve as transducers for high-frequency vibrations. Cobalt and nickel are magnetostrictive (Jan. '57, p. 162); barium-titanate ceramic is electrostrictive (Sept. '55, p. 173).

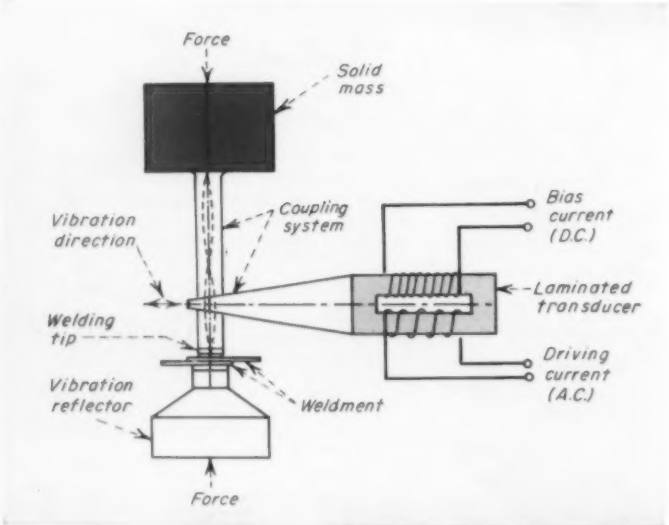
Power is supplied to the transducer from an electronic

1 Ultrasonic cleaning . . . ▸

of objects immersed in a treatment vessel results from violent cavitation throughout the liquid. Frequency is about 30,000 cps for the type of equipment illustrated. Optimum relationship exists between surface tension, vapor pressure and temperature of the liquid. Water plus a mild detergent is often used, but other liquids such as cyclohexane or trichlor-ethylene with lower viscosity are sometimes more suitable, especially for greasy articles. The liquid is usually heated to about 120 to 140 F for more effective cleaning. Small units such as this require about 450-w input to the ultrasonic generator. Water and oil cooling prevent excessive heating of the transducer.



4 Ultrasonic welding . . .



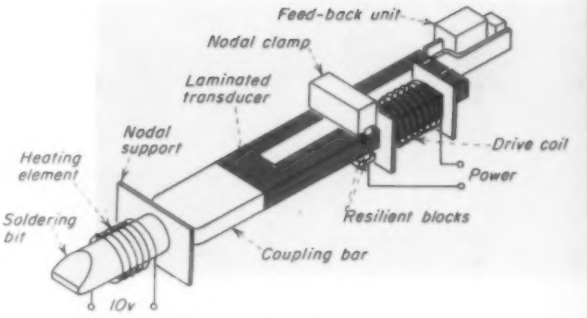
of similar or dissimilar metals gives metallurgical bond with low deformation, low clamping load, and no fusion. Pieces to be joined are clamped between two welding members. Vibratory energy briefly introduced produces a solid-state bond; the phenomenon occurs without high pressures or temperatures at the weld zone. Thicknesses can be 0.00015 to 0.040 in.

5 In thickness gage . . . ▸

transducer is applied to test piece and excited at varying frequencies, and an oscilloscope indicates amplitude of vibrations. Resonant frequency of test piece varies with thickness, and when the exciting frequency passes through resonance, the oscilloscope trace shows a peak which corresponds to a previously calibrated thickness. For curved test pieces such as pipe or bearing sleeves, curved crystals are used in searching unit. Accuracy of method is within 1%.

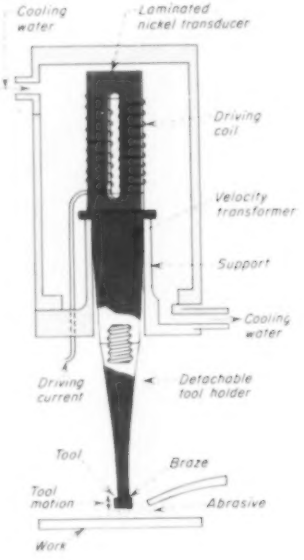
Transducers

oscillator, usually at frequencies from 20,000 to 60,000 cps for magnetostrictive transducers, and up to 500,000 cps for the electrostrictive type. The transducer is designed to be in resonance with the oscillator at such frequencies—which are in the ultrasonic range (above the frequencies of audible sound).



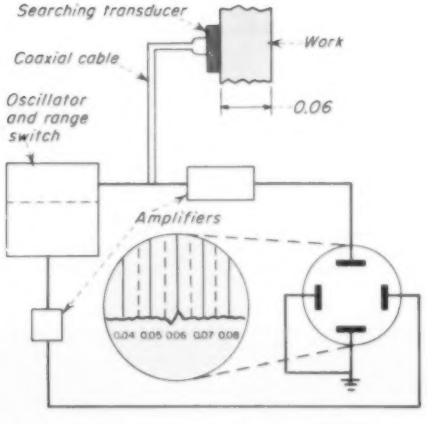
2 Vibrating tool . . .

can drill various materials such as hardened steel and glass. Hole shape will be the same as tool section and end face, hence intricate holes or cavities can be sunk quickly. Velocity transformer and detachable toolholder are specially shaped to increase amplitude of transducer vibrations. Cutting tool vibrates at about 20,000 cps on the axis of cone. Abrasive fed between tool and work grinds corresponding outline of tool in work area at about 0.01-0.30 in. per min depending on particle size, material, tool area and pressure. Power for ultrasonic drills varies from 50 w for small units to 2 kw for larger machines.



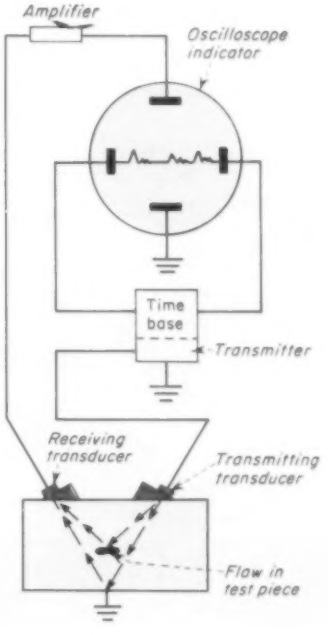
3 Aluminum soldering . . .

with ultrasonic vibrator can be done without flux. Oxide scale is loosened by cavitation. Soldering bit may be heated directly, or heat may be supplied to work by a hot plate or other external source. Resonance can be maintained by capacitance feedback at end of transducer, but this method, although inexpensive, is not considered efficient by some authorities. The system oscillates at 20,000 to 60,000 cps with an input of 50 w or more depending on bit size. Bits are interchangeable.



6 Flaws detected . .

by echo-sounding are mainly those in metals, but nonmetallic materials can be inspected by same method. One vibrating crystal transmits the wave; the other converts the reflected vibrations into electric impulses. Good acoustic contact is essential between transducers and testpiece surface. Film of oil or glycerine between surfaces is simple method for providing good contact. Surface roughness should be less than 125 micro-inches. As only a small volume can be inspected at one time, examination tends to be lengthy for large billets or castings.



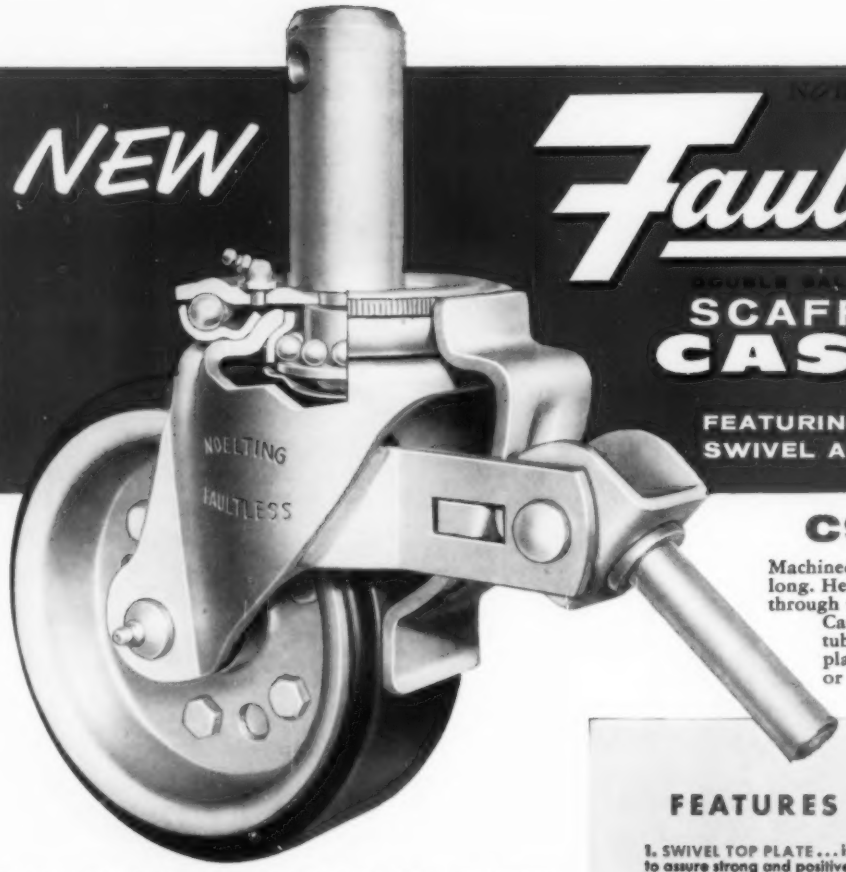
NOELTING

NEW Faultless

DOUBLE BALL BEARING

SCAFFOLD CASTERS

FEATURING SIMULTANEOUS SWIVEL AND WHEEL LOCKS



C900 STEM TYPE CASTER

Machined steel stem, 1⅜" dia. by 3⅝" long. Held securely in tubing by pinning through tube and 15/32" dia. hole in stem. Caster can be easily removed from tubing when necessary. For use on platforms, workstands, scaffolding or other items made of tubing.

To assure safe and positive handling of mobile equipment holding workmen, Faultless engineers have produced the most efficient method of applying dual locks ever offered for this important service. The Series C900 Swivel Stem and CP900 Swivel Plate Casters combine the famous (1) Faultless Double Ball Bearing Swivel, and (2) instantaneous locking protection of dual, quick-action brakes. Faultless, thus offers the ideal Caster for industrial, military and construction equipment.

For further information on the Series C900 and CP900 Casters ask for Faultless Bulletin No. 6957. Our experienced engineers will gladly consult with you on Caster problems, no obligation.

CP900 PLATE TYPE CASTER

Full ⅝" dia. king pin seats well below level of corrugated heavy steel top plate. Ideal Caster for use on flat base scaffolds, platforms, racks, stands, general purpose floor trucks.

FEATURES OF DESIGN

1. SWIVEL TOP PLATE ... is deeply serrated on outer edge to assure strong and positive contact with serrated surface of brake shoe. Top plate is hardened for added caster life.

2. SWIVEL BEARING ... consists of two complete rows of hardened ball bearings rolling in smooth, hardened and lubricated large diameter raceways.

3. BRAKE ASSEMBLY ... consists of heavy gauge, hardened, serrated steel brake shoe, guiding tabs, cam and lever arm; all permanently assembled in a steel frame that is welded to caster horn. Brake lever arm is in "down" position when brake is "off"... no danger of vibration causing brake to engage when equipment is being moved. Brake shoe and frame are deeply embossed for added strength. Brake can be operated easily by hand or foot. Cam and side tabs assure 100% brake shoe contact and compensate for wheel wear. This assures positive and effective braking of both swivel and wheel. Effective on both cushion or hard tread wheels. When brake is "off" brake shoe completely clears wheel and top plate for uninterrupted rolling and swiveling action.

4. THRUST BEARING ... raceway is machined from bar stock and fully hardened. Precision assembly assures free, easy swiveling action. Ball bearings are held in perfect alignment with hardened steel ball retainer.

5. GREASE FITTING ... conveniently located for positive thorough lubrication of swivel and load bearings. Same type fitting used for lubricating wheel bearings.

6. ROLLER OR BALL BEARINGS IN WHEEL ... assure easy rolling for long caster life and safe, smooth handling of equipment. Lubricated through pressure fitting in axle bolt head for complete, even distribution of lubricants to wheel bearings

7. WHEELS ... 5", 6", and 8" diameters available with Renewable Rubber Tires, Ruberex cushion tread composition Rockite hard tread composition, Plaskite and Semi-Steel Drawn Steel Wheel also available in 5" and 6" diameters

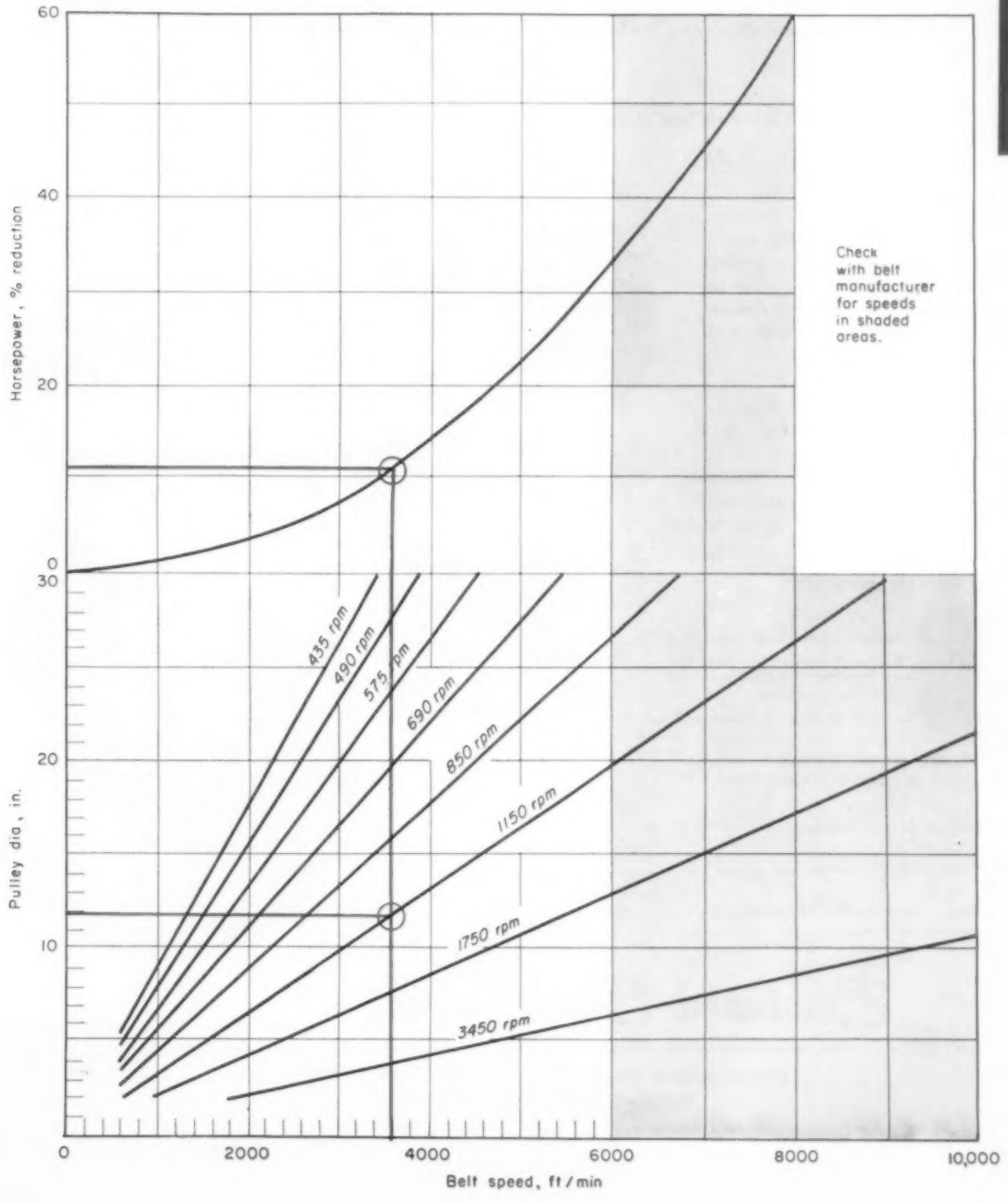
FAULTLESS CASTER CORPORATION, EVANSVILLE 7, INDIANA

Offices in Atlanta, Baltimore, Boston, Buffalo, Chicago, Cleveland, Dallas, Detroit, Grand Rapids, Greenville, S. C. High Point, Indianapolis, Los Angeles, New Orleans, New York, Philadelphia, Portland, Seattle, St. Louis. Canada: Stratford, Ontario.

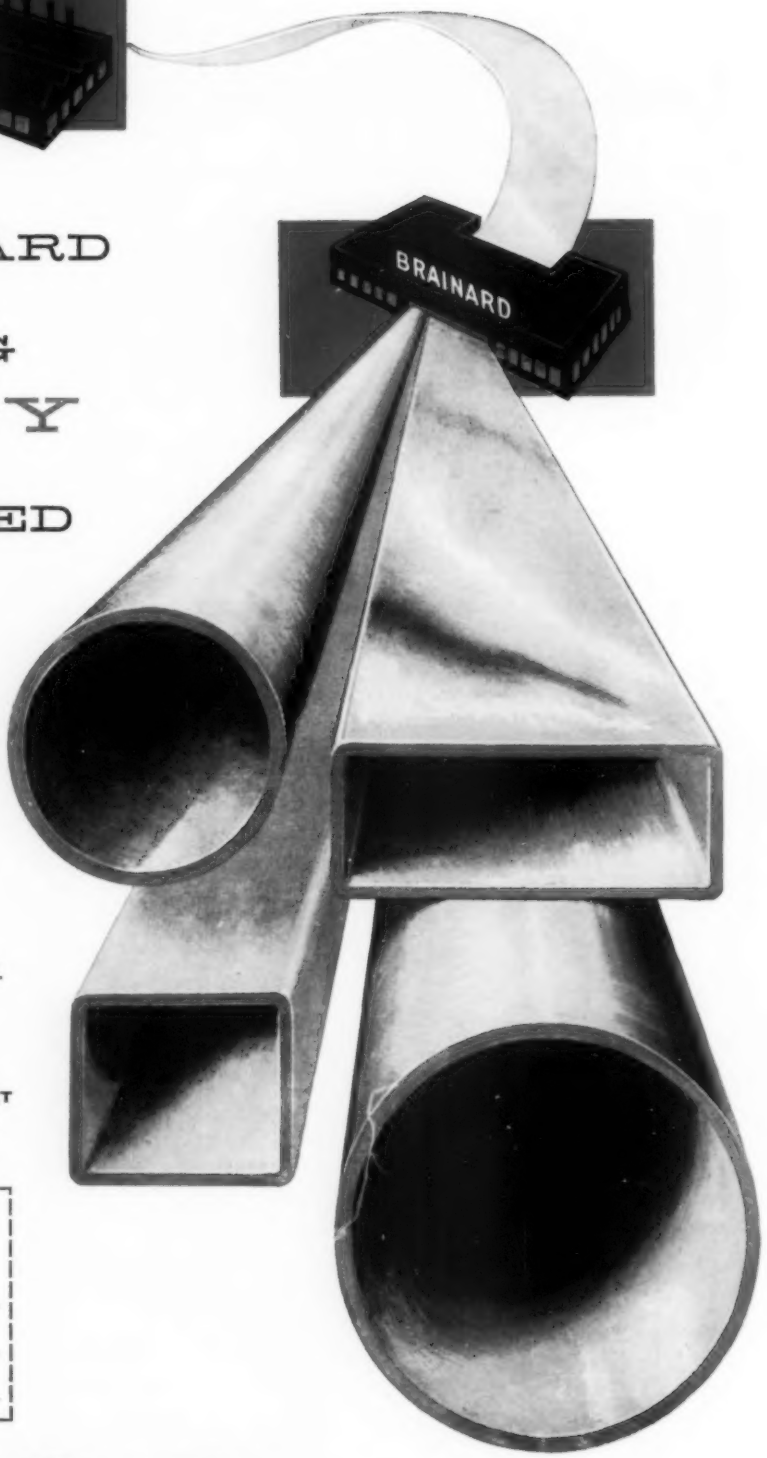
Leather Belts—Hp Loss and Speeds...

from 0-10,000 ft/min and 435-3450 rpm, for pulley diameters up to 30 in.

Horsepower ratings and correction factors for various leather belt sizes, tensions, and operating conditions are given by most engineering handbooks or manufacturers' catalogs. Such data, however, are usually not corrected for centrifugal force. This chart may be entered at any axis or pulley-speed curve. As shown, secants parallel to the axes connect any four values in correct relationship. In the sample construction, a 12 in. dia pulley at 1150 rpm gives a belt velocity of about 3620 fps at which speed there is a 12% hp reduction. Consult belt manufacturer regarding suitability, efficiency and other factors in high-speed applications.



IN BRAINARD STEEL TUBING QUALITY IS ASSURED



As a division of Sharon Steel, Brainard can be sure the steel used for the fabrication of tubing has been developed to meet their own exacting standards. From mine to finished product, Brainard Welded Steel Tubing has the extra quality that can come only from an integrated industry.

Brainard Electric Welded Steel Tubing, from ½" to 4" in diameter, is also available in squares, rectangles and many special shapes. Brainard Tubing can be furnished swedged, pressure tested, or fabricated.

For mechanical welded steel tubing of top value, buy Brainard.

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BRAINARD STEEL TUBING
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Name _____

Address _____

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Brainard Steel Tubing

SHARONSTEEL

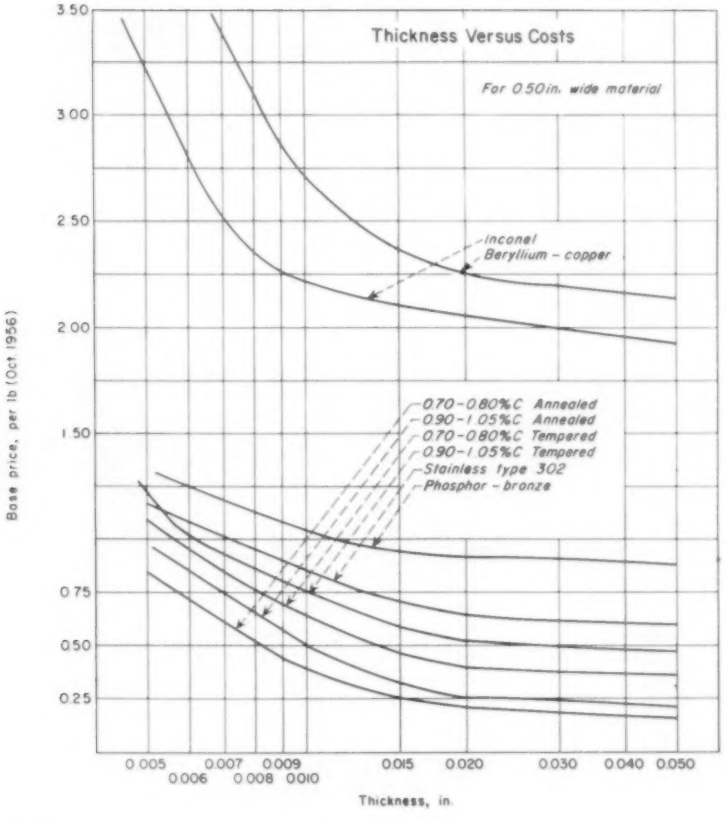
400

Brainard Steel Division, Sharon Steel Corporation
Griswold Street, Warren, Ohio

REFERENCE BOOK SHEET

Flat Spring Material— Costs and Stress Factors

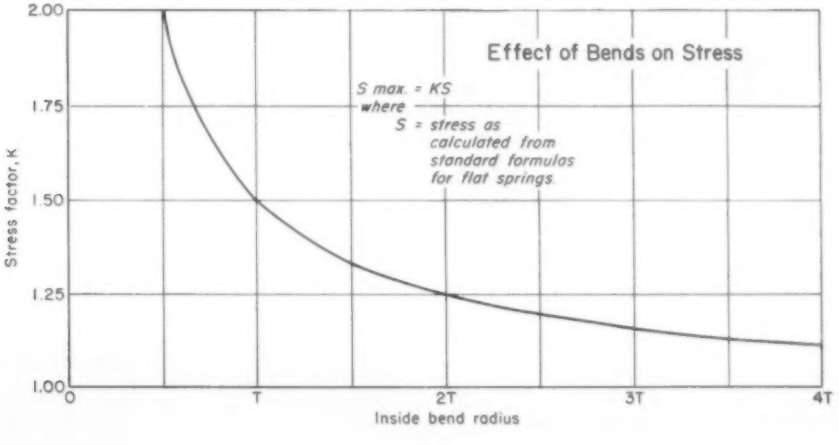
Effect of thickness on costs for 0.5 in.-wide tempered and annealed steel and non-ferrous alloys; stress factors for various bend radii.



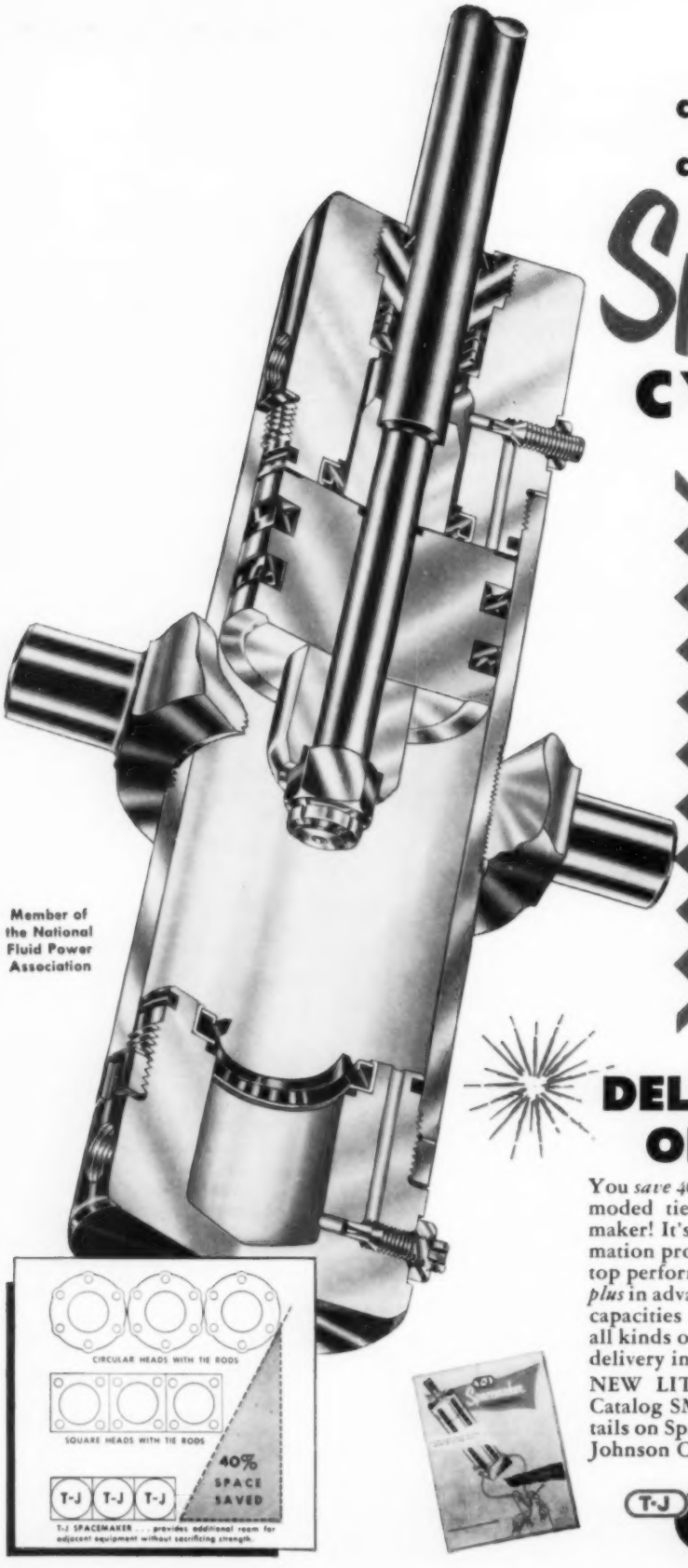
JOHN B. BECKWITH

Product Engineer,
Wallace Barnes Company Div.
Associated Spring Corp.

Although base cost may change, its variation with thickness remains fairly constant. Below 0.01-0.015 in. thickness there is generally a sharp increase in cost for spring materials. Choice of thickness is also frequently governed by strength factors when sharp bends are necessary. These charts provide a quick reference for thicknesses from 0.005 in. to 0.05 in., and bend radii up to four times the material thickness.



all the EXTRAS are standard with T-J Spacemaker CYLINDERS



Member of the National Fluid Power Association

- **NEW** *exclusive* ingenious cushion designs . . . Super Cushion Flexible Seals for Air . . . New Self-Aligning Master Cushion for Oil.
- **STRONGER** than outmoded tie rod design, proven through actual tests. No tie rods to stretch.
- **SOLID STEEL HEADS** throughout the full line.
- **COMPACT DESIGN** eliminates tie rods, increasing the strength and reducing mounting space required, providing extra room for adjacent equipment.
- **HARD CHROME PLATED** body bores and piston rods . . . assure you of long trouble-free service. (Standard at no extra cost.)
- **METALLIC ROD SCRAPER,** not just a wiper, actually removes foreign matter from the rod.
- **PILOTED PACKING GLAND** with extra long bearing. Additional strength and support to the piston rod.
- **OIL** pressure to 750 p.s.i. AIR to 200 p.s.i.

CIRCULAR HEADS WITH TIE RODS
SQUARE HEADS WITH TIE RODS
40% SPACE SAVED
T-J
T-J
T-J
T-J SPACEMAKER . . . provides additional room for adjacent equipment without sacrificing strength.

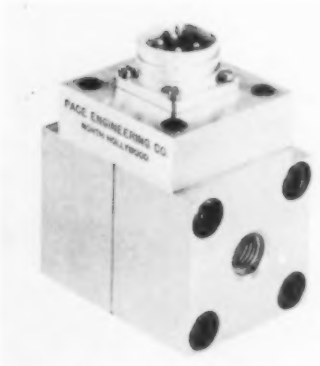
DELIVERY OFF THE SHELF!

You *save 40% space* when you switch from outmoded tie rod cylinders to the T-J Spacemaker! It's stronger, too! Fits right into automation programs in countless plants. Delivers top performance and dependability with a big *plus* in advanced features. Wide range of styles, capacities . . . reduces man-hours and costs in all kinds of push-pull-lift operations. Off-shelf delivery in 64,000 combinations!

NEW LITERATURE—Send today for new Catalog SM56 with complete engineering details on Spacemaker line. Write The Tomkins-Johnson Co., Jackson, Mich.

T-J TOMKINS-JOHNSON
RIVETORS . . AIR AND HYDRAULIC CYLINDERS . . CUTTERS . . CLINCHORS

NEW COMPONENTS and MATERIALS



Differential Pressure Transducer

A magnetic, reluctance-type pressure transducer measures low differential pressures at line pressures to 5000 psi. The transducer is offered in full scale ranges from 3 in. water up to 500 psi and is said to make possible static and dynamic pressure measurements accurate within ±1%, full scale. Indicating, recording and control systems compatible with inductance-ratio input devices can be used.

The pressure-sensing element is a diaphragm, magnetically coupled to a pick-off system embedded in the body. Mildly corrosive liquids and gases can be admitted directly to both sides. The unit weighs 2 lb and is about 1⅜ x 1⅜ x 2¼ in. long. Price, $2.50; delivery 4 to 6 wk. **Pace Engineering Co., 6914 Beck Ave., N. Hollywood, Calif.**

For more information—
Circle 1, inside back cover

Remote Counter

Control of this counter is with a five-wire cable brought out the back, terminating in a five-pin plug. The cable can be extended to any reasonable distance, and a simple switch at the extremity selects any digit from 0 to 9. Actuating voltage can be from 6 to 24 v dc.

The decade counter is designed to provide an output pulse at a selected number of rates in excess of 40,000 cps. If reset is not required, counting can be at a rate of 100,000-cps. Units are readily connected in cascade to emit a pulse at any desired count. Among typical applications are batching, sorting, packaging, automatic counting and controlling, frequency division, generation of precise delays. Price about $100; delivery about 3 wk in small quantities. **Computer Measurements Corp., 5525 Vineland Ave., N. Hollywood, Calif.**

For more information—
Circle 3, inside back cover

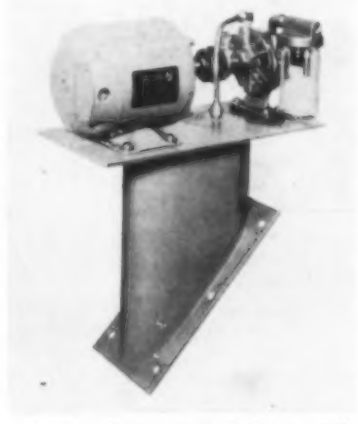
Digital Torque Measuring System

This measuring system is said to eliminate need for trunion-mounted dynamometers. It is applicable to electric-motor testing, engine and vehicle testing, shaft and transmission testing and to chemical or pharmaceutical mixing. Air propeller shaft torque is proportionate to viscosity.

A shaft-mounted torque pickup is coupled to a digital indicator. The pickup contains four strain gages mounted on the shaft periphery and connected in a bridge circuit. Output is obtainable through slip rings. The digital indicator contains a continuous-balance electronic potentiometer and a servo-balancing motor which drives number wheels.

Over-all system accuracy is coordinated to 0.25%. Output may be calibrated in either 16 ft or 16 in. of torque. The system is available in eight different capacities, from 100 to 3,000 lb-in. The indicator can be provided with coded digital outputs for connection to computers or remote recording stations. Price, $2750 including transducer; output for printer about $1000 extra. Delivery from stock in about 12 wk. **Performance Measurements Co., 15301 W. McNichols Rd., Detroit 35.**

For more information—
Circle 2, inside back cover



Partial Vacuum Eliminates Oil Leaks

This gear-case exhauster draws a partial vacuum in the gear case, substituting air flow into the case for oil leaking out of it. Work areas are said to stay clean, oil waste is eliminated and lower maintenance costs are obtained.

The exhauster is readily applied to a wide variety of gear cases by removing the conventional inspection plate and bolting in the exhauster. Vacuum air pump is driven through a flexible coupling by a ¼ hp motor. A filter tank, mounted between gear case and pump intake, removes oil from the evacuated air before it enters the rotary pump. Oil,

CONTINUED ON PAGE 128

Miniature Three and Four-digit Counter

Available in additive or subtractive types with manual reset wheels, these counters record pulses accurately to 1200 counts per min. Actuated electro-magnetically, the counters can be connected in vacuum tube plate circuits or operated by any contacting device.

A wide variety of mounting methods is possible and units can be furnished with or without panel mount cases. A snap-on cover for front of the case allows convenient resetting. Counters are available for all common voltages from 6 to 110 v dc, also for special d-c voltages.

Three-figure counter without case measures approximately $\frac{7}{8}$ x $\frac{7}{8}$ x 2 in. Weight of counter mechanism is 2 oz; mounted in die-cast case, 5 oz. Price: for three-figure unit with case, $20.65 to $27.50; without case, $18.70 to $24.75; four-figure with case, $22.85 to $30.25; without case, $20.20 to $26.95. Delivery 2 to 14 days, depening on quantity ordered. Approved for many military applications. **Abrams Instrument Corp., 606 E. Shiawassee St., Lansing, Mich.**

For more information—
Circle 5, inside back cover

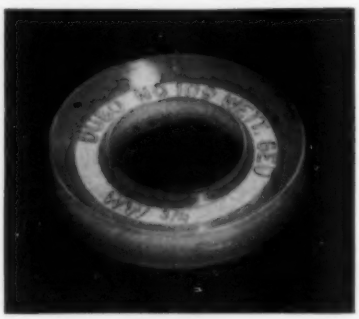
under gravity, flows back into the gear case without piping.

The pump maintains a vacuum of 3 to 5 in. of mercury, depending on the amount of leakage that may exist around gaskets and oil seals. Manufacturer has test installations on cases up to 8 ft dia. Price, $200 to $250, depending on pump size; delivery, 10 days. **A&A Mfg. Co., Inc., 712 S. 12 St. Milwaukee 4.**

For more information—
Circle 4, inside back cover

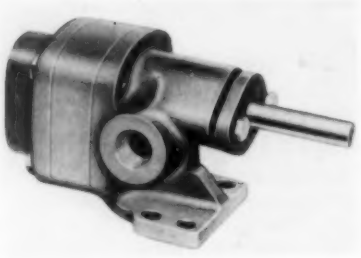
Double-ring Lock Washer . . .

a double V in shape, without threaded parts, is made of Nylon 6, a superpolyamide thermoplastic material. It fits over any screw or bolt; no threaded part or tool is necessary for application. When the ring is placed over a bolt and the nut is tightened, the inner diameter of the ring grips threads of the bolt and nut, and



flows into opening of the tapped hole. Simultaneously, the outer dia of the ring flows over the outer edges of the nut, securely locking and sealing. When the nut is unscrewed, the ring comes away with it. It can be used over and over without diminishing its locking and sealing powers. Washers have uniform locking torque and low installation torque. Can be used for electrical insulation to help control electrolytic corrosion as an insulator between dissimilar metals. Acquired shape is stable to 420 F. **Nylogrip Products, 449 Watertown St., Newton, Mass.**

For more information—
Circle 6, inside back cover



Heavy-duty Rotary Pumps . . .

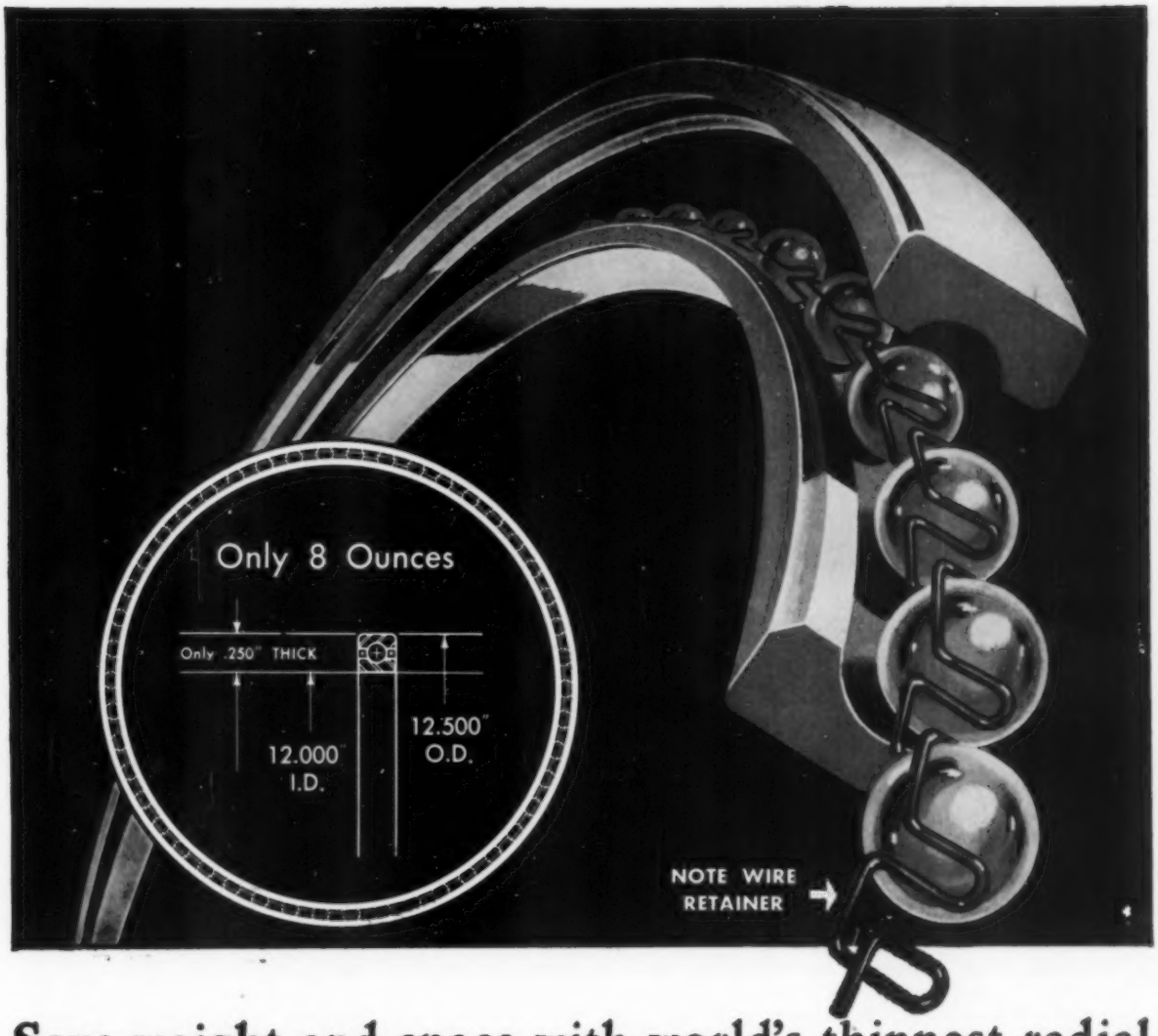
in sizes 1 through 4 are available for continuous-service applications at pressures to 500 psi in capacities to 25 gpm. Pump has suction and discharge openings from $\frac{1}{2}$ to 1 in. NPT. Pump has nodular iron herringbone gears; four force-feed lubricated roller bearings; replaceable steel-backed, bronze wear plates; and single stuffing box available with packing or mechanical seal for minimum leakage. **Worthington Corp., Harrison, N. J.**

For more information—
Circle 7, inside back cover

Thin Metal Parts Without Dies

A method that starts with photographing the drawing of the desired part onto sheets of sensitized metal, to $\frac{1}{16}$ in. thick, makes possible production of metal parts without dies. Parts are then etched free of surrounding metal. Offers economies for short runs and product development work, and is also feasible for large-scale production of many items. Practical for shapes too intricate for stamping, for close tolerances to ±0.002-in., and for parts where deburring is impractical and costly. Setup charge is $25.00; parts from

CONTINUED ON PAGE 130



Save weight and space with world's thinnest radial ball bearings—*Reali-Slim* by Kaydon

HERE it is! A *Reali-Slim* radial ball bearing with a wire separator that has just short of a full complement of balls for maximum capacity. What's more, you still get all the advantages of a separator between the balls. This design also gives you a bearing that's light-in-weight and is, without a question, the thinnest bearing ever built in this diameter.

Whatever your product design, there's a small or large diameter *Reali-Slim* bearing that can be the right answer to your thin-section bearing problems.

The radial ball bearing, illustrated here, is *really slim* — 12.000" I.D., 12.500" O.D., .250" thick . . . *and weighs only eight ounces.* It has 9,810 lbs. static load capacity, 1,256 lbs. at 100 rpm. Kaydon is able to produce *Reali-Slim,* high-precision bearings because Kaydon specializes in the unusual.

Kaydon bearing engineers are prepared to give you valuable help with technical, thin-section bearing problems.

For detailed information on Kaydon's *Reali-Slim* line, ask for engineering catalog No. 54-RS3 detailing:

Reali-Slim Ball Bearings — Conrad, angular contact and 4-point contact types in seven standard cross sections from ¼" to 1.000" and in bore diameters from 4" to 40".

Reali-Slim Roller Bearings — Radial and taper roller types in cross sections from 9/16" and in bore diameters from 5" to 40".

THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

K-561

All types of ball and roller bearings — 4" to 120" outside diameter . . .
Taper Roller • Roller Thrust • Roller Radial • Bi-Angular Roller • Needle Roller • Ball Radial • Ball Thrust Bearings.

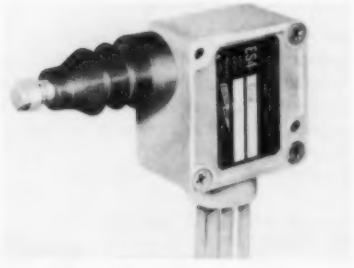
15¢ each, depending on size and thickness (0.02 to 0.16 in.). Delivery on initial orders, to 3 wk. **Randolph Co., 1018 Rosine, Houston, Tex.**

For more information—
Circle 8, inside back cover

Five-way Hydraulic Control Valve . . .

has been developed for the more complicated hydraulic circuits now going into materials-handling equipment. In the center position, the valve connects straight through to the single-acting cylinder, with other ports closed. In either of the end positions, it connects to a double-acting cylinder and closes the port to the single-acting cylinder. Standard valve is suitable for pressures to 2000 psi. **Mechanisms Co., 118 E. 2 St., Uhrichsville, Ohio.**

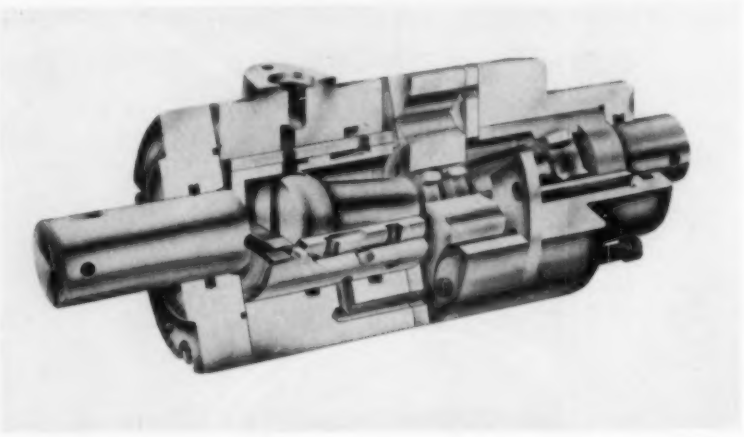
For more information—
Circle 9, inside back cover



Limit Switch With One-way Action . . .

is said to eliminate complicated one-way dogs, extra switches and relays. The die-cast switch gives simultaneous, one-way action on two poles, resulting in an electrical impulse on the inward stroke, and does not operate the switch on its return to normal position. Snap-action of the four-circuit switch mechanism is totally independent of speed of plunger movement. It is claimed to be excellent for pulsing electrical control on both pneumatic and hydraulic valves and similar installations requiring momentary, one-way electrical impulses. Simultaneous break of two poles permits flexibility in wiring. Rated for 15 amp, 125/250 v ac, 30 v dc operation. Housed in an aluminum die-cast case with splash-proof neoprene boot. **Electro Snap Switch & Mfg. Co., 4218 W. Lake St., Chicago 24.**

For more information—
Circle 11, inside back cover



Hydraulic Torque Booster

This device operates with a small torque signal applied to the input shaft and, through a servo valve and hydraulic motor, delivers a corresponding movement of the output shaft against comparatively heavy torque loads. Output shaft duplicates movement of the input shaft, regardless of direction of rotation, and is not limited to part of a revolu- or a few revolutions. It will operate in continuous rotation at speeds to several hundred rpm.

The torque-generating hydraulic motor uses a rotor that consists of an inner and outer ring. Commonly, each of these parts revolves around its own fixed centear, or at a different speed. In this hydraulic motor, the outer ring is held stationary and the rotor turns inside the ring on a center which describes a circle.

With this construction, the rotor becomes a fluid displacement mechanism and also operates a a gear-reduction unit.

The basic design is intended for universal application with manifold inlet and outlet ports that may be adapted to many installations. Hydraulic-motor units in two sizes have been built and tested. Model S-104 is $4\frac{7}{8}$ in. x $9\frac{1}{4}$ in. Torque output at 1000 psi is 1100 in-lb. Operating speed is 23 rpm per 1 gpm. Maximum speed is 200 rpm. Model S-103 is $4\frac{11}{32}$ in. x $8\frac{29}{32}$ in. Torque output at 1000 psi is 615 in-lb. Operating speed is 33 rpm per 1 gpm. Maximum speed for both units is 200 rpm.

Any rotary control or power shaft that requires a power boost can be adapted to utilize the unit. Suggested uses include machine tools for power drives of feed screws and spindles, electronic controls where small input signal may control a large rotary output, automation applications, control for the marine field, power steering for vehicles, boats, aircraft, printing equipment, large photographic and x-ray machine controls, and atomic reactors. **Char-Lynn Co., 2843 26 Ave. S., Minneapolis 6.**

For more information—
Circle 10, inside back cover

Data Read-out Counters . . .

combine visual indication with electrical read-out for remote indication, recording, and controlling applications. Electrically

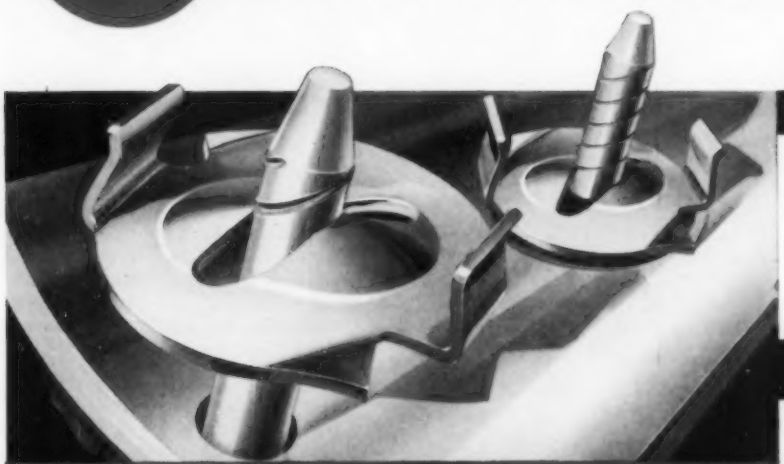
CONTINUED ON PAGE 132

DOT

THREAD CUTTING FASTENER

HOLDS TIGHT TO CURVED SURFACES

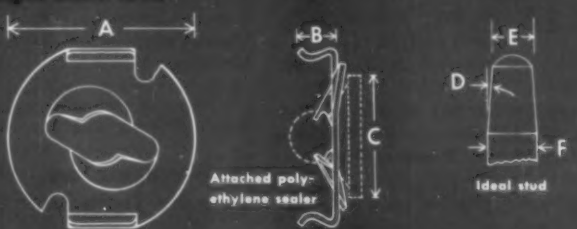
- Low Cost
- Re-Usable
- Self-Locking
- Vibration-Proof
- Spring Take-Up



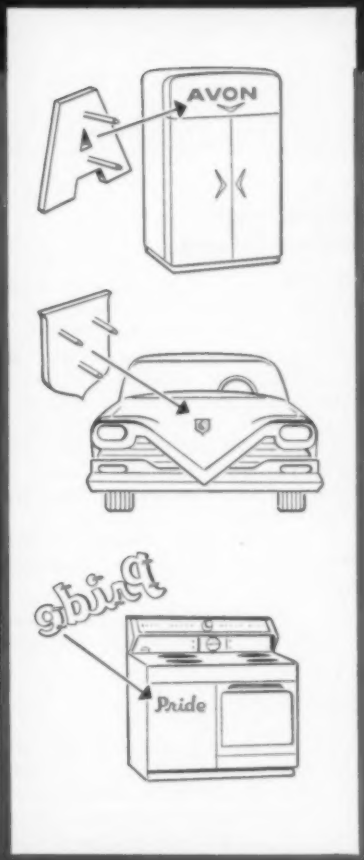
Specially designed to hold die-cast or cold-forged name plates, emblems and trim against sheet metal surfaces . . . DOT'S unique T.C.F. can be used in many other applications which require a spring take-up fastener that pulls up tight without backup on flat or contoured surfaces.

It cuts clean, deep threads on unthreaded studs, even those that are chrome plated. When used with its preassembled plastic sealer, T.C.F. makes a water-tight seal. The sealer *precedes* the fastener onto the stud so that it is not damaged by the thread-cutting process.

Available *in quantity*, with or without sealer, to fit 1/8" and 3/16" studs. Drawings available on request for magnetic tool or simple hand tool.



Nominal Sizes	A	B	C	D	E	F	Driving Torque	Ultimate Strength
1/8"	.560	.170	.450	6°/4°	.095 .085	.130 .125	7-10 Inch lbs.	200 lbs.
3/16"	.705	.200	.450	6°/3°	.160 .150	.192 .184	20 - 30 Inch lbs.	400 lbs.
1/4"	.875	.260	.625	6°/4°	.190 .180	.255 .245	25-30 Inch lbs.	500 lbs.

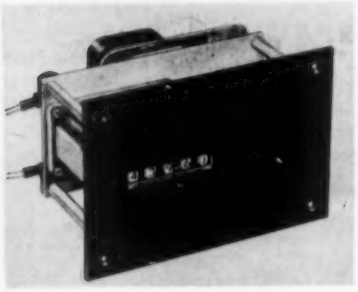


Manufactured by
MONADNOCK MILLS SUBSIDIARY
San Leandro, Cal.

DOT T.C.F.
Patent Pending

Manufactured by
CARR FASTENER CO. DIVISION
Cambridge, Mass.

UNITED · CARR FASTENER CORPORATION



or mechanically driven, and provided with manual or electric reset, the counters present a display of accumulated totals and automatically create specific control-circuit contact closures for each number visually displayed. Each instrument, with its five-figure capacity, provides 100,000 distinct circuit arrangements. Counters are compatible with standard data processing equipment. **Veeder-Root, Inc., Hartford 2, Conn.**

For more information—
Circle 12, inside back cover

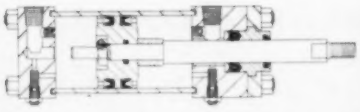
High-strength Silicone Rubber . . .

strong enough to replace organic rubber in many applications has a tensile strength of 1600 psi; tear strength is 200 to 250 lb/in. Elongation is 650 to 850%. Can be fabricated and cured by all conventional methods of handling silicone rubber; molded in thick section components or extruded with wall thicknesses of 0.010 in. or less; tinted to obtain a variety of colors, including white; compounded with fillers to obtain hardness greater than its normal 50 durometer. **Silicone Products Dept., General Electric Co., Waterford, N. Y.**

For more information—
Circle 13, inside back cover

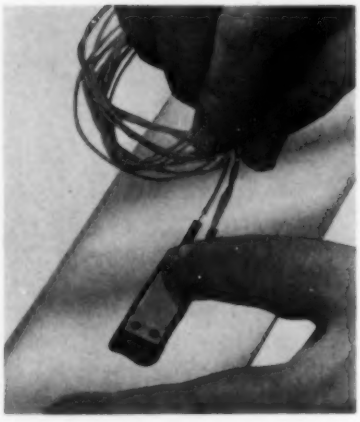
Square Air Cylinders . . .

operate to 200 psi, air or oil. The line conforms to JIC pneumatic standards. Piston rod is high tensile, turned, ground and polished shafting, hard chrome plated, 0.001 in. dia. Piston is positively locked on the rod with nut and grub screw. U-cup piston packing, chevron rod packing and rod scraper are homogeneous synthetic rubber. Cushion bushing, plunger and piston are finished-machined after assembly to assure concentricity. Shell is cold-drawn seamless steel tubing, honed to 15-20 micro in., either cadmium or



hard chrome plated. Rod bearing and cushion bushing are bearing bronze. Heads are cold-rolled steel. Available with 1½ in. through 10 in. bores in a complete range of mounting styles. **Lynair, Inc., 3100 Michigan Ave., Jackson, Mich.**

For more information—
Circle 14, inside back cover



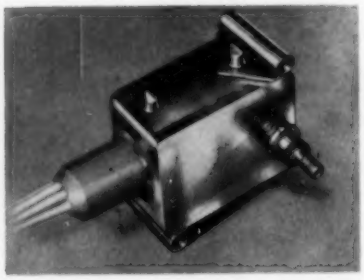
High-temperature Strain Gage . . .

operates to 1100 F. Available in standard, rosette and cross types. Strain-sensitive element is Karma wire. Nominal resistance is 120 ohm and gage factor is 2.25. Each unit is furnished with 6-ft-long glass-fiber-covered Nichrome V lead wires and an adequate supply of AP-1 ceramic cement for installation. **Columbia Research Laboratories, Woodlyn, Penn.**

For more information—
Circle 15, inside back cover

Rotary Switch . . .

is designed for aircraft landing gear and engine controls, missile launchers, radar and industrial equipment. Two hermetically-sealed basic switches are combined in this switch, and the model shown includes an actuator shaft that can continuously rotate 360° in either direction; other models have limited-rotation shafts or are spring-returned. Connectors, potted leads and choice of actuators are optional. Current capacity is 10-amp resistive, 30 v dc, 115 v ac. Measures $1\frac{63}{64}$ x $1\frac{15}{32}$ x $1\frac{1}{32}$



in. Unaffected by ambient temperatures from −65 F to 275 F. The switch is also shock- and vibration-resistant. A heavy nickel-plated steel case increases protection. **Spencer Thermostat Div., Metals & Control Corp., Attleboro, Mass.**

For more information—
Circle 16, inside back cover

Fast-curing Phenolic Molding Material . . .

is a wood flour filled compound for general-purpose moldings, particularly electrical components, with physical and electrical properties comparable with other general-purpose molding materials. The two-step material was developed specifically for use in cold-powder automatic molding, but may be used in most types of molding equipment. Curing speed increases with mold temperature. Preheating ensures the fastest curing speeds. Recommended preheating times are about 40% less than for a fast one-step material; about 20% less than for a typical two-step material. **Bakelite Co. Div., Union Carbide Corp., 260 Madison Ave., New York 16.**

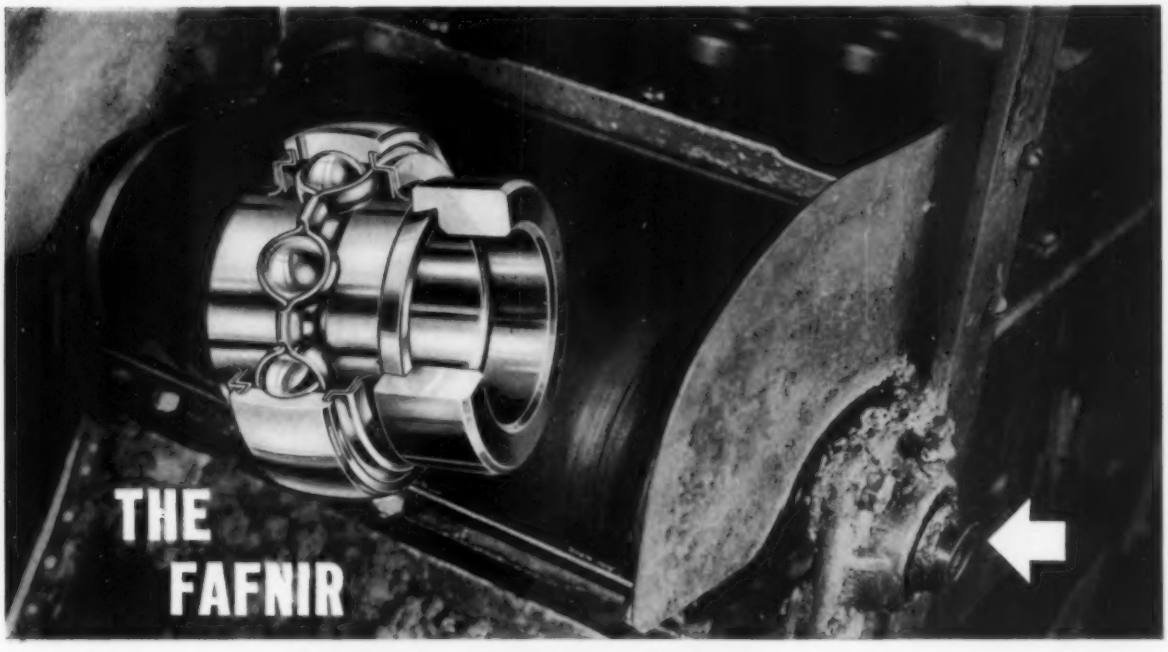
For more information—
Circle 17, inside back cover

High-temperature Pressure Transducer . . .

permits pressure measurement to 5000 psig under unfavorable environmental conditions. Available in gage pressure ranges of 100, 150, 250, 500, 1000, 1500, 2500, 3500 and 5000 psi, and can be operated continuously at 5-v max input over a temperature range of −350 F to 600 F with allowable transients to 750 F. Linearity and hysteresis deviations combined are less than ±1.5% of full-range output, as measured from a straight line drawn through the full-scale end points. Construction of the instrument suits it to such applications as static and dynamic testing of pressure systems ranging from

CONTINUED ON PAGE 134

TWO GREAT BEARING DEVELOPMENTS ROLLED INTO ONE!



PLYA-SEAL WIDE INNER RING BALL BEARING

Designed expressly for slow speed applications and wet or dirty operating conditions

New Fafnir Plya-Seal Wide Inner Ring Ball Bearings are a combination of two outstanding bearing developments. The most effective seal ever devised for retention of grease and protection against contamination, plus the famous Fafnir self-locking collar, for cost-cutting, twist-of-the-wrist bearing installation. This combination of features offers you several advantages . . .

Best protection yet against dirt, dust, steam, water, lint, other contaminants on slow to moderate speed applications. Contact-type, Plya-Seals seal out abrasive or corrosive material, seal in factory prepacked lubricant.

Less Maintenance — In many applications, non-relubricatable bearings may be used. They require virtually no maintenance time or expense. In other applications, where bearings receive hard or constant use, relubricatable types are available. They require only occasional greasing, even under severe conditions.

Longer Service life — Plya-Seals protect against premature bearing wear or failure. Contaminants cannot damage balls or races; sealed-in lubricant ensures against bearing "running dry".

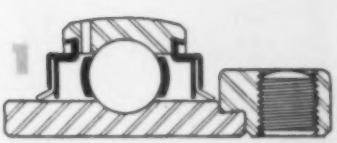
Simplified Designing — Bearing housings may be designed without incorporating separate housing seals. Plya-Seals provide full protection; make possible simplified, less costly, more compact housings.

Power Transmission Units incorporating new Fafnir Plya-Seal Wide Inner Ring Bearing

RAK and RAS Type Pillow Blocks | RCJ Type Flange Cartridges | Fafnir Flangettes

Write for bulletin containing complete specifications on Fafnir Plya-Seal Wide Inner Ring Ball Bearings and Power Transmission Units. The Fafnir Bearing Company, New Britain, Conn.

FAFNIR
BALL BEARINGS
MOST COMPLETE LINE IN AMERICA

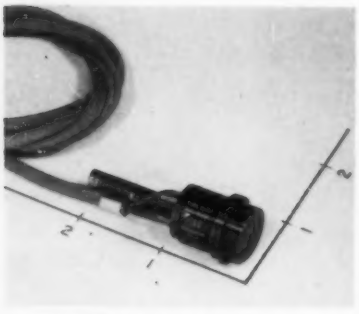


PLYA-SEALS

As incorporated in the Fafnir Plya-Seal Wide Inner Ring Ball Bearing, the Fafnir Plya-Seal consists of a synthetic rubber-impregnated fabric sealing washer sandwiched between dished steel plates. Seal flares out, maintaining constant contact with ground outside diameter of inner ring. Years of service have proven Plya-Seals the most effective seal ever developed for ball bearings.

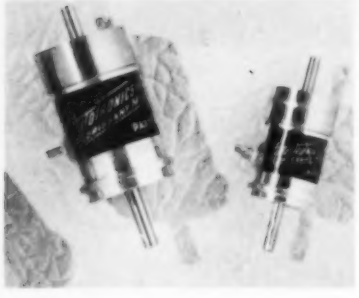
SELF-LOCKING COLLAR

Originated by Fafnir, this famous development has cut costs and simplified assembly throughout industry. Bearings slip onto shaft; are locked securely with simple twist of self-locking collar. No need for lock nuts, shoulders, sleeves, washers, or adapters. Positive binding action increases with use.



temperatures of liquid-oxygen stems to those of hydraulic systems in rockets and supersonic aircraft. Unit is $\frac{5}{8}$ in. dia, $\frac{3}{4}$ in. long, and weighs 30 gm. **Consolidated Electrodynamics Corp., 300 N. Sierra Madre Villa, Pasadena, Calif.**

For more information—
Circle 18, inside back cover



Servo-mounted Electromagnetic Brake . . .

operates when not energized, making it possible to brake a servo motor with power on. Made in four models with minimum brake torque 2 to 30 oz-in. Over-all dimensions from 0.593 x 0.942 in. length to 1.370 x 1.745 in. length, excluding output shaft. Standard models operate at 24 v dc. Shaft alterations, controlled torque and voltage requirements from 6 to 100 v dc are available. Units meet military specifications for vibration. **Autotronics, Inc., Route 1, Box 812, Florissant, Mo.**

For more information—
Circle 19, inside back cover

Power Transmission Belt . . .

that will not slip or stretch, will operate at speeds to 24,000 fpm and to 6000 hp, at ratios to 20:1 and arcs of contact to 90°. The belts are said to handle shock loads up to seven times the normal running loads. Belt is combination of a special type of polymer and chrome-tanned leather. Polymer has a tensile strength of 28,000 psi; modulus of elasticity is 78,230 psi. The leather acts only as a friction surface. **Extremultus, Inc., 405 Lexington Ave., New York 17.**

For more information—
Circle 20, inside back cover

Self-bonding Metal Nameplate . . .

applies in 10 sec and requires no activation by water, solvent or heat. The 0.004-in. aluminum plate is backed with a pressure-sensitive adhesive that adheres to metal, glass, plastic, wood, painted, smooth, flat, wrinkled and curved surfaces. Available in a wide range of colors, glossy or matte finish. The legend is imbedded in deep-anodized colors. The plates are said to stay bonded to surfaces through a temperature range of —62 F to 325 F. **W. H. Brady Co., 727 W. Glendale Ave., Milwaukee 9.**

For more information—
Circle 21, inside back cover

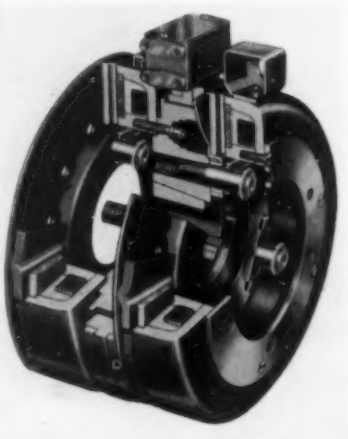
Line of Fhp Motors . . .

has been designed especially for application where operating conditions are abnormal. Motors are single-phase, 60 cps; and three-phase, 60 to 50 cps. Motors are totally closed, of nonventilated construction, with base welded to stator shell, and have stainless steel shafts. Available with ratings of $\frac{1}{6}$ through $\frac{3}{4}$ hp; speeds of 3450, 1725 and 1140 rpm. **General Electric Co., Schenectady 5.**

For more information—
Circle 22, inside back cover

Magnetic-friction Clutches and Brakes . . .

operate on the principle of electromagnetic engagement of the armature and the field magnet to develop driving or braking torque. The disk-type friction brakes and clutches feature: simplicity of controls, which may be remotely mounted to conserve space on the processing equipment; rapid response in clutching and braking; smooth engagement of the friction members; effective cooling; automatic adjustment, and low maintenance cost. The basic clutch, the basic brake, the clutch-brake and the clutch coupling are now in production in a wide range of



capacities. Corresponding parts of all units in a given size are completely interchangeable. **Dynamatic Div., Eaton Mfg. Co., Kenosha, Wis.**

For more information—
Circle 23, inside back cover

Self-locking Bolt . . .

designed as four-way answer to the problem of bolt assemblies, is vibration-proof, liquid-tight and adjustable, and locks wherever wrenching is stopped. The nylon plug that provides locking action is unaffected by age, immune to fungus, will not dry out or shrink. In No. 10 to 1-in. dia sizes. **Bolt & Chain Div., Republic Steel Corp., 1970 Carter Rd., Cleveland 13.**

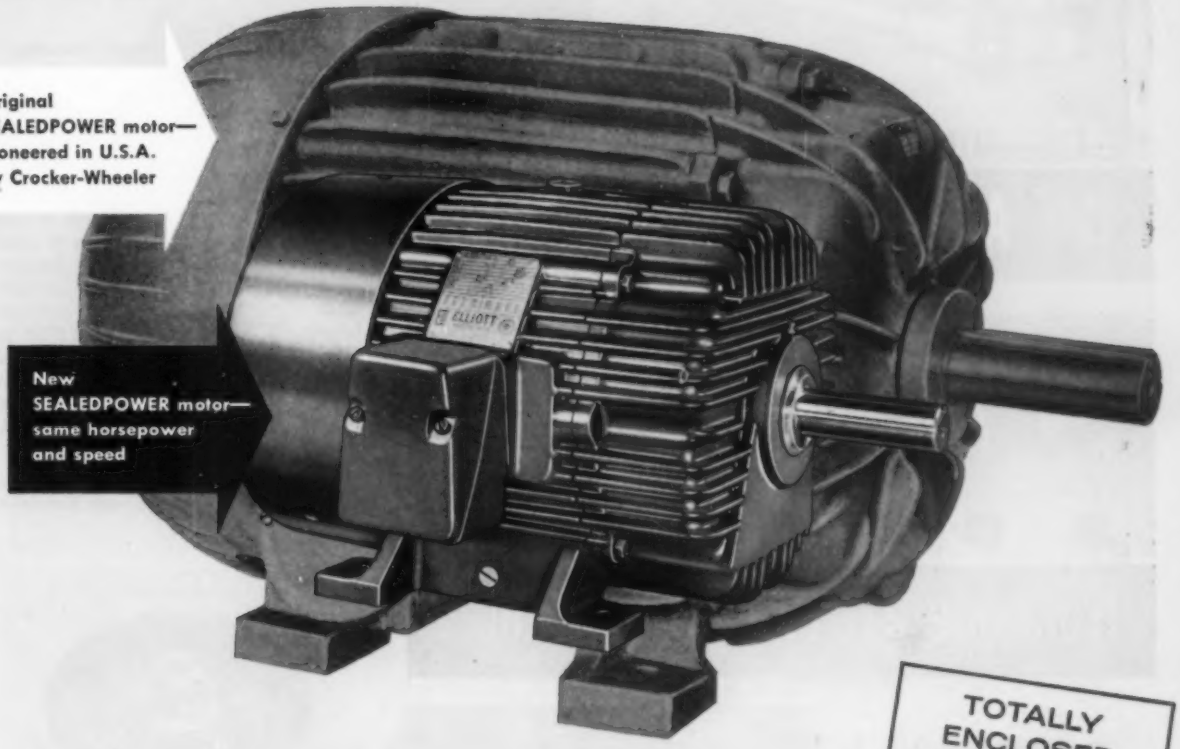
For more information—
Circle 24, inside back cover

Self-locking Screws . . .

have also proved themselves as highly effective seals against liquids. Plastic locking element seals threads against fluid

CONTINUED ON PAGE 136

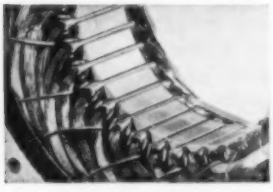
Inside and Outside . . . entirely new


Original SEALEDPOWER motor—pioneered in U.S.A. by Crocker-Wheeler
New SEALEDPOWER motor—same horsepower and speed
ELLIOTT

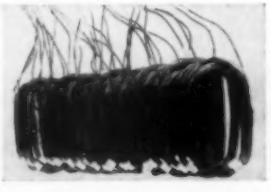
TOTALLY ENCLOSED FAN-COOLED FRAMES 284U-326U

NEW Elliott SEALEDPOWER Motors Produce MORE POWER per POUND

Superior Insulation Improves Motor Performance



Stator slots are lined with new, revolutionary synthetic materials having greater dielectric and mechanical strength than those previously used.

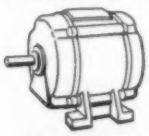


Motor coils are group-wound from continuous lengths of Vinylastic wire, with no brazed or soldered connections within groups.

In the new Elliott Crocker-Wheeler Type N motors, better utilization of copper, insulation, and electrical steel produces more horsepower per pound than earlier designs.

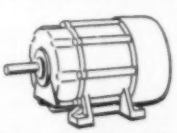
This is one of the *balanced design* factors that contribute to the outstanding performance of these motors. Others are highest quality electric steel, rigid frames and brackets, choice of anti-friction bearings to suit your operating and maintenance conditions, and a variety of highly effective enclosures, including dripproof, totally-enclosed and explosion-proof designs.

OTHER C-W TYPE N MOTOR ENCLOSURES



Totally-enclosed non-ventilated

Dripproof Protected



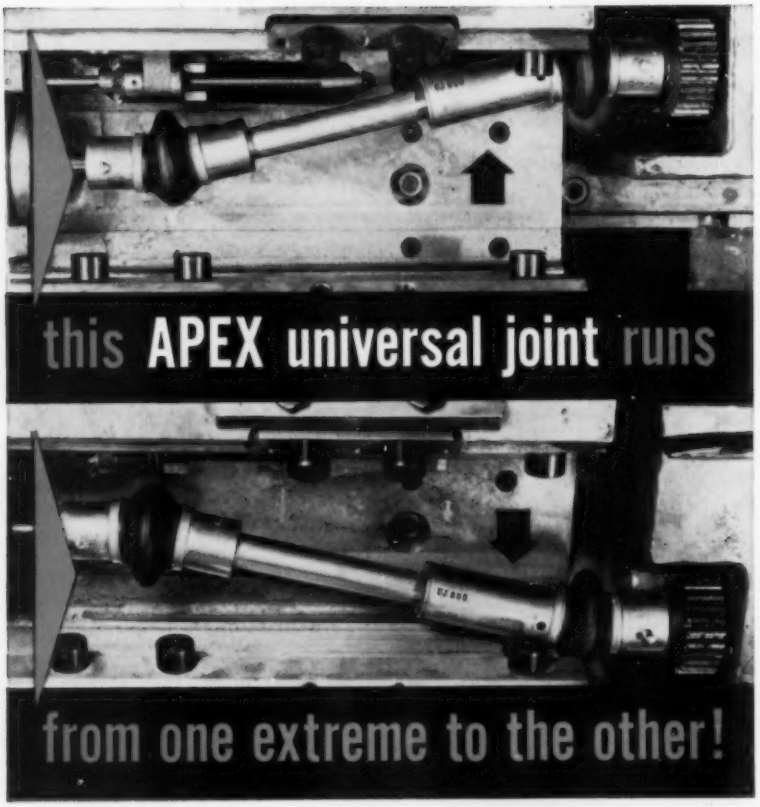
Totally-enclosed, fan-cooled Frames 256 U and smaller

ELLIOTT Company

CROCKER-WHEELER DIVISION

***WRITE* for new bulletin describing Elliott C-W Type N Motors. *Address:* Elliott Company, Crocker-Wheeler Division, Jeannette, Penna.**

W6-7



Automation — simple, practical, efficient. That's the Sheffield Press Pacer, a flexible, completely mechanical transfer system that moves stampings through every die position, from load to eject.

Down in the heart of the Sheffield Press Pacer—a mechanical transfer system—is an Apex double universal joint. It is subjected to constant start-stop service. Both joints operate continuously at angles up to 35°, moving from one extreme to the other as the system runs through its cycle. The joints are protected from oil and dirt by flexible covers, exclusive with Apex, that also assure clean, sustained joint lubrication.

For this *special* application, Sheffield uses a 1½" diameter Apex double universal joint assembly. Designed and built to serve the more difficult drive-line applications, Apex universal joints could solve your design problem. Catalog 28 provides the information you need; write, on your company letterhead please, for your copy.

THE APEX MACHINE & TOOL CO.
1039 South Patterson Blvd.
DAYTON 2, OHIO

Phantom view of APEX covered universal joint which operates efficiently in wet or dry, corrosive or abrasive atmospheres, and in extremes of temperatures.

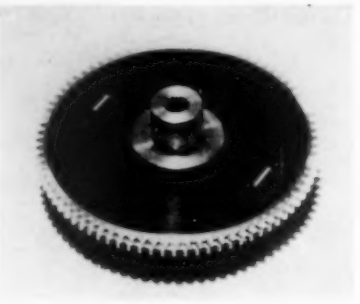
leakage to pressures of 2250 psi. This is of particular interest in fuel tanks, fuel systems and hydraulic applications. **Long-Lok Corp., 2018 Colorado Ave., Santa Monica, Calif.**

For more information—
Circle 25, inside back cover

High-speed Transmission Belt . . .

is capable of operating at speeds to and above 100,000 rpm over pulleys as small as ⅜ in. dia. The flexible, thin, flat belt is a blend of stretch-resistant synthetic and natural fibers. It has been operated successfully at 100,000 rpm for 2100 hr over a ⅞ in. dia pulley. Can be used at any spindle speed even though it was specifically developed for ultra-high-speed transmission. **Russell Mfg. Co., 468 E. Main St., Middletown, Conn.**

For more information—
Circle 26, inside back cover



Anti-backlash Gear Assemblies . . .

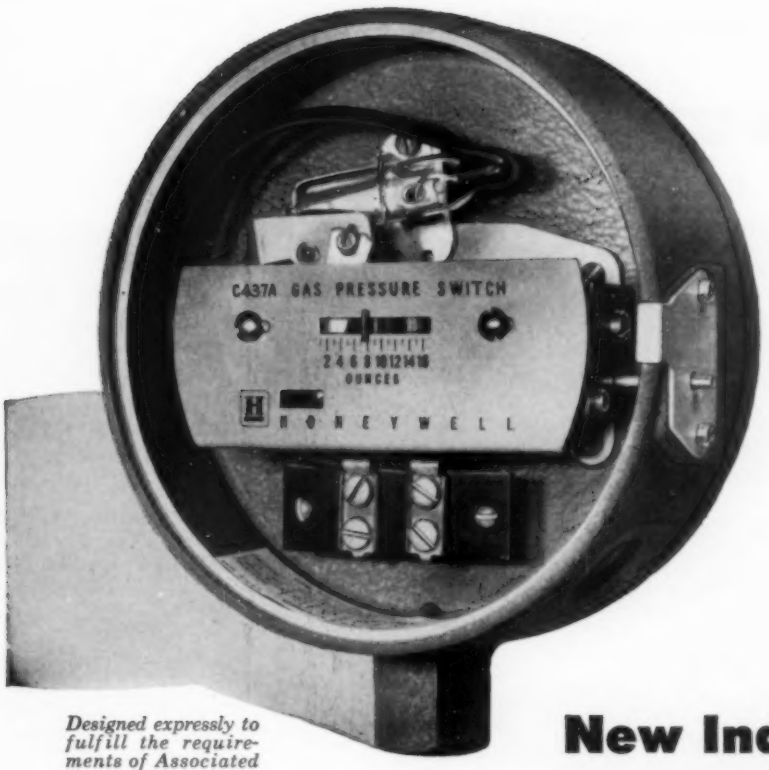
from stock are offered in aluminum and stainless steel for ⅛, 3/16, and ¼ in. shafts. Gears are available in set screw and clamp-type hubs. AGMA precision I and II gear teeth and pitches in a wide variety, such as 48, 64, 72, 96 and 120 pitches with 20° pressure angles, are available. **PIC Design Corp., div. Benrus Watch Co., Inc., 477 Atlantic Ave., East Rockaway, N. Y.**

For more information—
Circle 27, inside back cover

Mylar-insulated Metal Screw . . .

replaces screw-and-insulating-tube assemblies. The screw may be of any metal, depending on end use. Insulation is provided by the polyester film between the fastener and parts assembled with it. The unit cuts inventory and permits savings

(Continued on page 141)



Designed expressly to fulfill the requirements of Associated Factory Mutual.

New Industrial Gas Pressure Switch offers 4 exclusive safety features

USE this new Honeywell C437A Industrial Pressure Switch as a safety cutoff on multiple burner gas installations . . . as a pressure controller for hazardous gases . . . or as a differential controller for air or non-hazardous gases. It's simply designed, yet provides complete protection.

The C437A Industrial Gas Pressure Switch has these exclusive safety features:

1. Sealed Pressure Chamber—Should the diaphragm rupture from over pressure or any other cause, gas can't escape into the switch compartment or to the atmosphere. The pressure chamber is fitted with a pipe tap to permit venting to the stack.

2. Protected Settings—All adjustments are inside the case for protection against careless or accidental manipulation. A metal plate on the side of the case must be removed before changes in adjustment can be made.

3. Ever-Visible Switch Position and Control Settings—The entire cover of the pressure switch is a window. Position of the mercury switch and adjustment of the control settings can be determined at a glance.

4. Lockout Mechanism—An optional safety feature, when manual resetting is desired. The lockout mechanism prevents the switch from remaking contact after pressure has once dropped below the setpoint . . . even though pressure returns to normal. The lockout release button is the only adjustment that can be manipulated without removal of the protecting metal plate.

For complete information, call the nearest Honeywell office. A Honeywell sales engineer is as near as your phone.

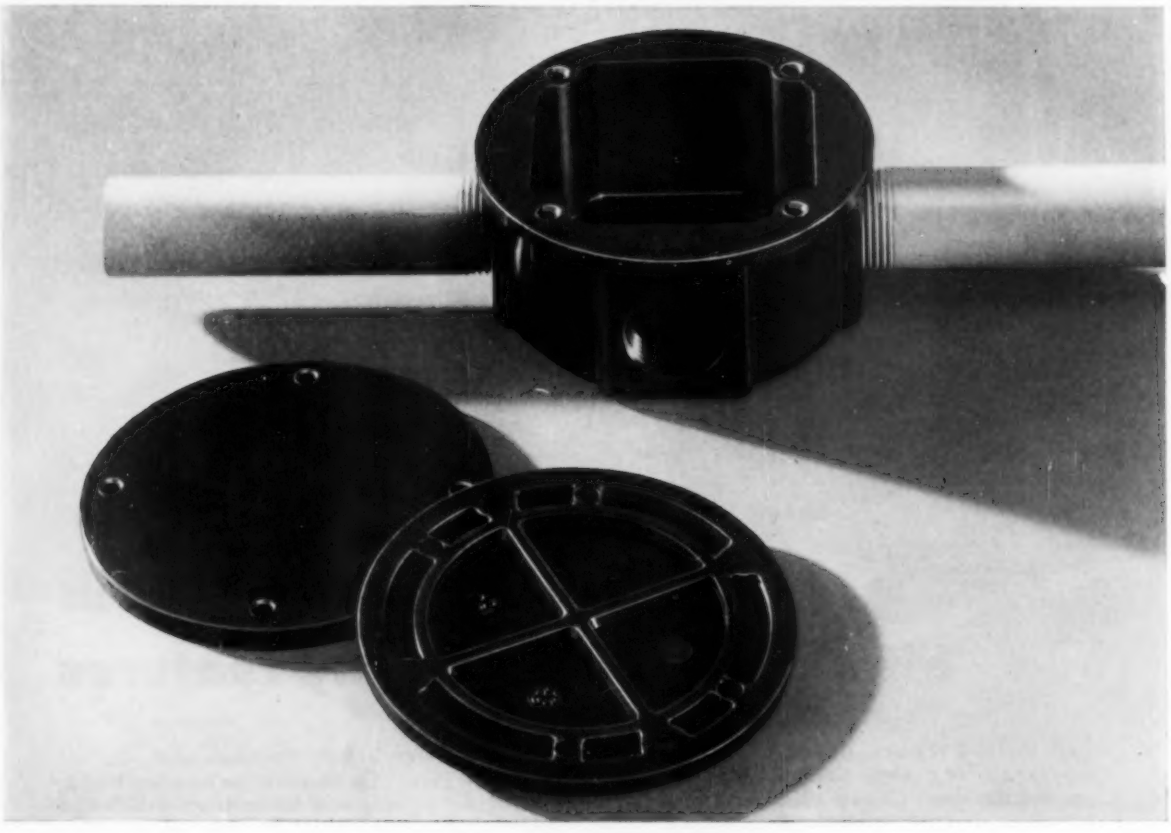
MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.

● **REFERENCE DATA:**
Send for Specification S1011-1 Honeywell Gas Pressure Switch C437A

MINNEAPOLIS Honeywell
BROWN INSTRUMENTS
First in Controls

If one of many requirements is

IMPACT STRENGTH



...get the others too with DUREZ PHENOLICS

Here is another example of how engineering with Durez phenolic plastics created a product that serves better...sells better...costs no more and often less than the one it replaces.

Impact resistance was high on the list of properties required by Union Insulating Co. in designing a non-corrosive conduit junction box for hospitals, chemical plants, and other industrial services. The material to be used also had to be tough, free from warp, dimensionally stable, and light in weight. It had to resist heat, oil, grease, moisture—and corrosion-laden atmospheres. Electrical properties had to meet modern industrial requirements.

Durez checked okay on all counts, Union design engineers found. Specified for its molded AO-4 boxes, Durez results in a superior product at no greater production cost. Customers go for its longer service and reduced maintenance.

The advantages your products could gain with these most widely used phenolics merit investigation. Talk your needs over with your molder... or let us send you engineering data on Durez.

DUREZ®

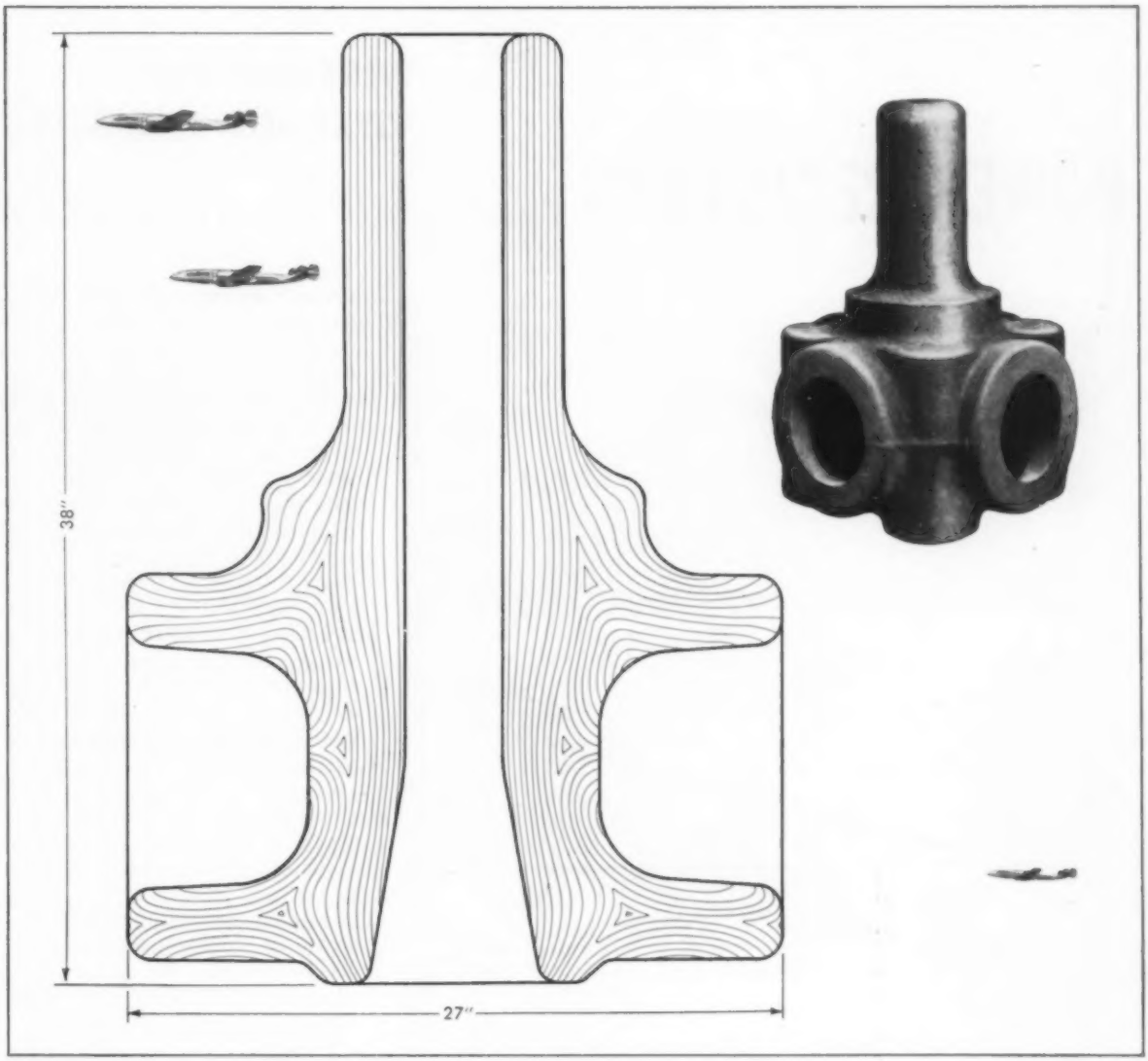
Plastics that Fit the Job

DUREZ PLASTICS DIVISION

HOOKER ELECTROCHEMICAL COMPANY

1510 WALCK ROAD, NORTH TONAWANDA, N. Y.

HOOKER® CHEMICALS PLASTICS



THE SPLIT-DIE FORGING SOLUTION FOR TURBOPROP TORSION

This big Turboprop propeller hub for Curtiss-Wright was turning up a storm in design circles. Specifications called for 2680 lbs. of A.I.S.I. 4355 modified aircraft quality steel to be forged and heat treated to high strength levels, all of which is not unusual except for one thing. The tremendous power transmitted through the neck section of the hub subjected this area to unusual stresses. Grain structure was a prime consideration. This presented a problem because conventional forging methods could not produce the desired grain flow pattern.

The Cameron split-die forging process solved the problem for Curtiss-Wright. In a single pass through Cameron's largest side-ram press, a glowing billet was pierced from six different directions and changed into the near final shape shown above. Grain structures were exactly right. As an added benefit, far less machining time was required to complete the hub.

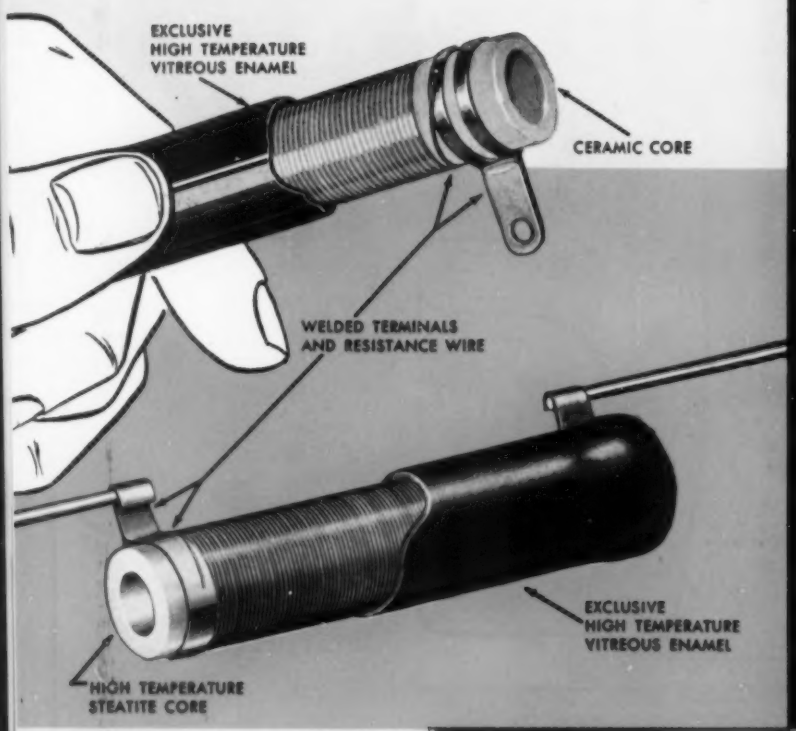
This hub is a striking example of Cameron's ability to economically solve design problems through the use of a new forging concept. Shapes and sizes formerly considered impossible to forge in closed dies have become routine procedure with this revolutionary technique. If you have a component problem that forces you to accept castings where forging quality is desired, or if conventional forging processes fail to give you the metallurgical quality or economy that you require, write, call or come by . . .

Cameron
IRON WORKS, Inc.
SPECIAL PRODUCTS DEPARTMENT
P. O. Box 1212, Houston, Texas

OHMITE®

WIRE-WOUND, VITREOUS-ENAMELED

POWER RESISTORS . . . *industry's most complete line*



WELDED RESISTANCE WIRE Ohmite Resistors have the resistance wire welded to the terminals instead of soldered or brazed. This provides a perfect and permanently stable electrical connection that is unaffected by vibration or high temperature.

WELDED TERMINALS Another Ohmite Resistor feature is the welded terminal band. The band is permanently held together around ceramic core by means of welding, providing a strong, permanent fastening.

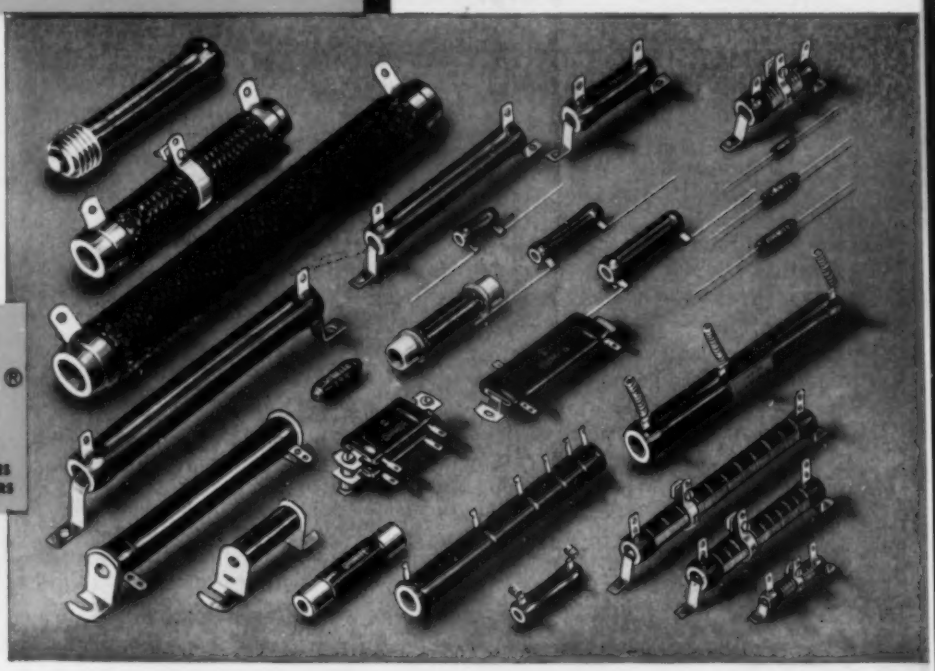
STRONG CERAMIC CORE This strong, rugged core has excellent electrical characteristics, and is unaffected by cold, heat fumes, or high humidity.

EXCLUSIVE HIGH TEMPERATURE VITREOUS ENAMEL This special-formula enamel was developed by Ohmite after extensive research. Its thermal expansion is properly related to that of core, terminal, and resistance wire.

Ohmite offers resistors in more than 60 sizes—ranging from 2½" diameter by 20" long to ¼" diameter by 9/16" long—to meet your exact requirements. MANY SIZES ARE CARRIED IN STOCK.

Ohmite offers the most complete line of wire-wound, vitreous-enameled POWER RESISTORS on the market . . . fixed, adjustable, tapped, noninductive, and precision resistors in many sizes, types of terminals . . . available in a wide range of wattages and resistances.

Write on company letterhead for Catalog No. 40.



BE RIGHT WITH

OHMITE®

RHEOSTATS • RESISTORS • RELAYS • TAP SWITCHES
TANTALUM CAPACITORS • VARIABLE TRANSFORMERS

OHMITE MANUFACTURING COMPANY
3611 Howard Street
Skokie, Illinois

in assembly cost. Diameter of the insulated shank is the same as the outside dia of the threaded section of the screw so smaller assembly holes are needed and width of the blades and spacers can be narrowed accordingly. Produced to the user's specifications. **Pylon Co., Inc., Attleboro, Mass.**

For more information—
Circle 28, inside back cover

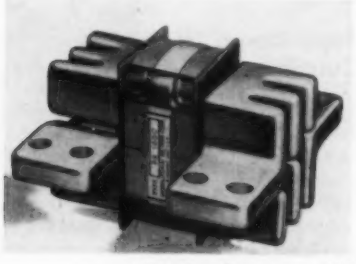
Miniature Phase-sensitive Ac Voltmeter . . .

is available in single-range and multi-range models. The panel-mounting instruments are designed to be built-in to test equipment and operating equipment in military and industrial applications. The zero-center units provide indications equal to the product of signal magnitude and cosine of phase angle between signal and reference voltages. No controls or operating adjustments are required. Single-range instruments have sensitivities from 10 mv on each side of zero while multi-range models can be as low as 6 v. **Trio Laboratories, Inc., 4025 Merrick Rd., Seaford, N. Y.**

For more information—
Circle 29, inside back cover

16-amp Paralleling Reactors . . .

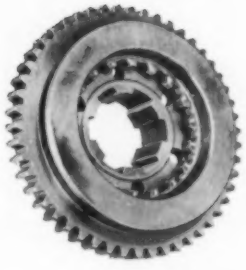
will equalize current distribution to selenium stacks, germanium and silicon rectifiers operated in parallel, variable transformers, adjustable reactors and rheostats.



(Continued on page 142)

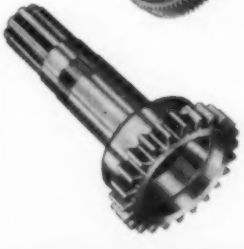
There is
only ONE Best Gear Design
for each application

. . . and SIER-BATH manufactures it into your gears



Sier-Bath serves you with the best gear design, engineering and manufacturing service. You get free engineering consultation and the finest gears to meet the increased requirements of tomorrow.

Sier-Bath designed and manufactured gears give you the same operating advantages that have brought leadership to many other machinery manufacturers.



No other gear company can now give you
PRECISION CROWN-GROUND SPUR GEARS
to 12″ diameter, 4 pitch

Send us your gear prints or specs for study and quotation—or have a Sier-Bath gear specialist call to discuss the steps that will make us your ideal gear department.

All kinds of gears—all materials.
Made—cut—shaved—ground tooth.
48″ maximum diameter
12 or more of a kind, depending on size

Sier-Bath PRECISION GEARS

Sier-Bath GEAR & PUMP CO., Inc.
9238 HUDSON BOULEVARD NORTH BERGEN, N. J.
Founded 1905 Members A.G.M.A.

Also manufacturers of Rotary Pumps and Flexible Gear Couplings

SEALING DOMESTIC APPLIANCES IS A REAL CHALLENGE, TOO!
Standard 6A Seal with specially designed seat conforming to impeller contour so as to promote good water flow characteristics.
Limited axial room and large diameter are mechanical requirements in this washing machine seal. Design features multiple spring construction for even face loading.
FIVE ADAPTATIONS OF THE John Crane TYPE 6A SEAL for four different appliance manufacturers
Seal features outer periphery face construction to best service garbage disposal conditions.
Two sealing points in a washing machine with widely differing physical limitations, yet seals for both retain full advantage of diaphragm action, shouldering points and positive drive.

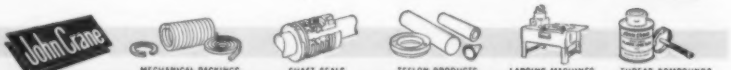
Soapy water, detergents, bones, grit and lint . . . all these combine to make appliances a hard-to-handle sealing problem. Add that to a very limited space factor, and you've got a real set of conditions on your hands.

"John Crane" engineers have solved these problems and thousands of other shaft sealing applications on all types of commercial and industrial equipment. We know that we can be of the same help to you.

That's why . . . as one design engineer to another . . . we urge you to let us work with you in adapting or developing the proper seal for your application.

Tell us about your requirements or write for our fully illustrated Bulletin S-204-3 on "John Crane" Shaft Seals.

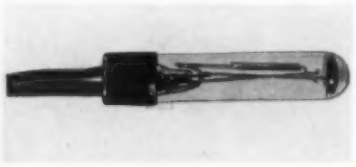
Crane Packing Company, 6445 Oakton Street, Morton Grove, Illinois, (Chicago Suburb). *In Canada: Crane Packing Co., Ltd., Hamilton, Ont.*



CRANE PACKING COMPANY

Rated for a 50-C temperature rise, with normal convection cooling. When air-cooled, 1000 linear ft per min, rating can be increased to 2200 amp rms. Unit can be used to assure equal voltage distribution in the paralleling of bridge-type circuits, multiple groups in parallel, or multiple strings in series. Protected against adverse atmospheric conditions. **International Rectifier Corp., 1521 E. Grand Ave., El Segundo, Calif.**

For more information—
Circle 30, inside back cover



Magnetically Actuated Mercury Switch . . .

is hermetically sealed in hydrogen atmosphere with platinum contacts wetted in clean mercury to provide trouble-free operation. The SPDT, 1-amp, 115-v ac switch has high sensitivity, to 60 operations per sec. **Hamlin, Inc., 1316 Sherman Ave., Evanston, Ill.**

For more information—
Circe 31, inside back cover

Closed Cellular Rubber Extrusions . . .

can now be tailored to virtually any required shape. A variety of cord, tubing and other extruded shapes is already in production. Processed neoprene rubber is used for cord and miscellaneous shapes, and processed Buna-n vinyl for hollow tubing. Closed cellular rubber is softer and more workable than solid rubber because its structure, individually sealed cells, contains inert nitrogen. It is also lightweight, durable and moisture- and vapor-resistant. **Rubatex Div., Great American Industries, Inc., Bedford, Va.**

For more information—
Circle 32, inside back cover

Taper-bored Flexible Couplings . . .

for use with taper bushings have been developed to reduce normal stock requirements of coupling bodies; make available a wide range of shaft sizes within the reduced stock; and give a coupling-bushing combination that affords easy fastening to the shaft with the firmness of shrunk-on

(Continued on page 146)

For BETTER CONTROL of FLUIDS...

Specify *Norgren* CONTROL VALVES

DIAPHRAGM TYPE VALVES

Automatically protect against damage from excessive pressure build-up. Provide controlled operation for fluid recirculating systems.

Easily adjusted to relieve at desired pressure. Relief settings: 0-15 psi, 0-50 psi, 0-75 psi, 0-125 psi, 0-250 psi for pipe sizes ⅛" through ½", and 0-15 psi, 0-50 psi, 0-75 psi, 0-125 psi for ¾" and 1" pipe sizes.

POP SAFETY VALVES

Prevent the build-up of dangerous, excessive pressures in air tanks. Valve automatically pops open at desired setting. Pipe sizes ⅛", ¼", ⅜" and ½".

LOW FLOW RELIEF VALVES

Small, inexpensive valves suited for a wide variety of uses requiring relief at low rates of flow. ⅛" and ¼" pipe sizes.

FLOW CONTROL VALVES,
Two-Way—Single-Way

For accurate control of air and hydraulic cylinders. Provide large volume flow with low pressure drop, easily and quickly regulated. ¼", ⅜" and ½" pipe sizes.

NEEDLE VALVES

Tapered needle provides controlled metering of air, liquids and gases that do not affect brass. Leak-proof. Choice of five types in ⅛" and ¼" pipe sizes.

For complete information, call your nearby Norgren Representative listed in your telephone directory... or

WRITE THE FACTORY FOR NO. 800 CATALOG

C. A. NORGREN CO.

Wherever Air is Used in Industry

3428 SO. ELATI STREET • ENGLEWOOD, COLORADO

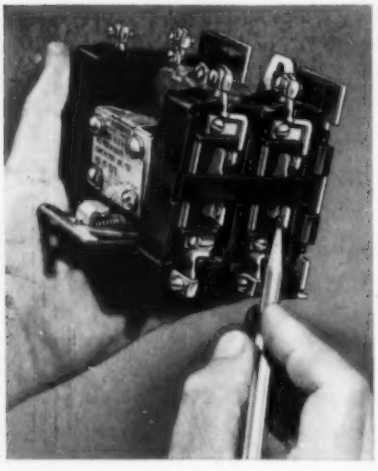
The Panelbuilder

65 YEARS OF SERVICE
CUTLER-HAMMER
MOTOR CONTROL
C-H

News for and about Panelbuilders

CONTACTS EASILY CONVERTED ON C-H MULTI-POLE CONTROL RELAYS, NO NEW PARTS NEEDED

Cutler-Hammer's 9575 family of multi-pole control relays was designed to facilitate simple, quick contact conversion. To convert a normally open contact to a normally closed contact, or vice versa, the stationary and movable contact members are simply reversed . . . no special parts or tools are required. Not only does the versatility of the 9575 control relay simplify on-the-job contact conversions, but also many panel builders prefer to stock their



Cutler-Hammer Relays by the number of poles and arrange the contacts to suit each specific relay application as the relay is drawn from stock. Cutler-Hammer 9575 Multi-Pole Control Relays are available from 2 to 8 poles. For further information write for Bulletin 9575.

Space Saving Heavy Duty Oil-Tight Control Units Provide Greater Circuit Flexibility

To meet the demand for smaller, more flexible heavy duty oil-tight pushbuttons, indicating lights and selector switches, Cutler-Hammer developed the 10250T family of control units. These units, adaptable for either one-hole mounting or base-mounting, offer amazing opportunities for simplified compact control panel design.

Back-of-Panel Depth—1 3/32"

Cutler-Hammer's pushbutton units are available as either flush button, extended button or mushroom head operators. When one-hole-mounted, a double pole pushbutton unit extends only 1 3/32" behind the panel. The double pole contact blocks are available in any combination of normally open and normally closed contact. Each circuit is mechanically and electrically isolated from the other. For additional circuits, contact blocks can be quickly tandem mounted. No special attachments required. Operators come in six distinctive colors.

Indicating Lights Include PresTest

Cutler-Hammer 10250T oil-tight indicating lights, either resistor type or transformer type, have 180 degree non-blinding lenses. These unusually compact lights are available in six brilliant colors, with either unbreakable plastic or heavy glass lens. PresTest, the famous self-testing indicating light, permits instant checking for faulty bulbs without dismantling the unit. Merely by pressing on the PresTest lens, the bulb is disconnected from the normal circuit and checked on a separate test circuit.

Roto-Push—The One-Button Control Station

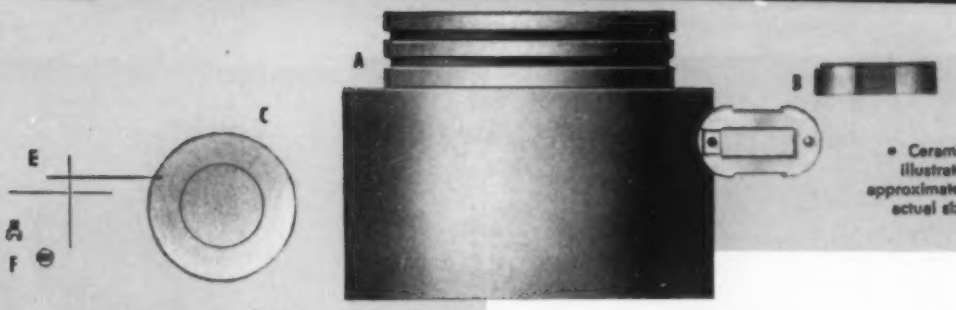
Cutler-Hammer's Roto-Push is a single unit that combines the functions of the push-button and selector switch. Available in either two or three position types, the guard ring rotates to select the desired function while the push-button actuates the circuit. Roto-Push offers practically unlimited circuit combinations and often it will replace two or three units. Cutler-Hammer's 10250T family also includes a complete line of two and three position selector switches in a variety of operators.

C-H Master Design

For complete information of Cutler-Hammer's 10250T family of control units write on your company letterhead for C-H Master Design, Pub. EL-178.

PANEL BUILDERS HANDBOOK SIMPLIFIES SELECTION OF ELECTRICAL COMPONENTS

This handy 67 page reference guide is specifically edited to assist design engineers and control panel builders in the selection of electrical control components and control accessories. Every effort was made to make this book as concise as possible, and yet it includes such vital information as wiring diagrams, dimension drawings, ratings, ordering information and a maintained price list. Address your request for a personal copy on your company letterhead. CUTLER-HAMMER, Inc., 1332 St. Paul Ave., Milwaukee 1, Wisconsin.



• Ceramics illustrated approximately actual size.

ALSIMAG®
PRECISION CERAMICS

produced to precision tolerances

New equipment and techniques are constantly added to improve precision. Few people—few engineers—are aware of the close tolerances which are now possible. There are 3 main reasons for this progress:

COMPOSITIONS. Widest range in the industry. Some AlSiMag materials are hard as sapphire — more wear resistant than tool steel — and are non-magnetic and chemically inert. New Alumina "super ceramics" perform unbelievable feats of strength, thermal and mechanical shock resistance plus excellent electrical characteristics at ultra high frequencies and temperatures. Improved characteristics promote ruggedization, permit miniaturization.

CONTROLS. In preparation of raw materials, designing and building dies, calculating shrinkages . . . at every manufacturing step — forming, firing, inspecting. Over 55 years of experience — where precision in ceramics was pioneered!

FINISHING. Equipment plus skill. Every machine for precision finalizing. Thoroughly trained personnel who consider difficult specifications a personal challenge.

Tell us about your component problems. AlSiMag Precision Ceramics may do a better job for you. Send us a blueprint or sketch with an outline of the operating procedure for complete details.

Do you know.....

that ceramics can be supplied, in quantity: To tolerances generally associated with precision metal work.

A. Pistons and cylinders with maximum clearance of as little as .0015".

B. With faces parallel within .0005".

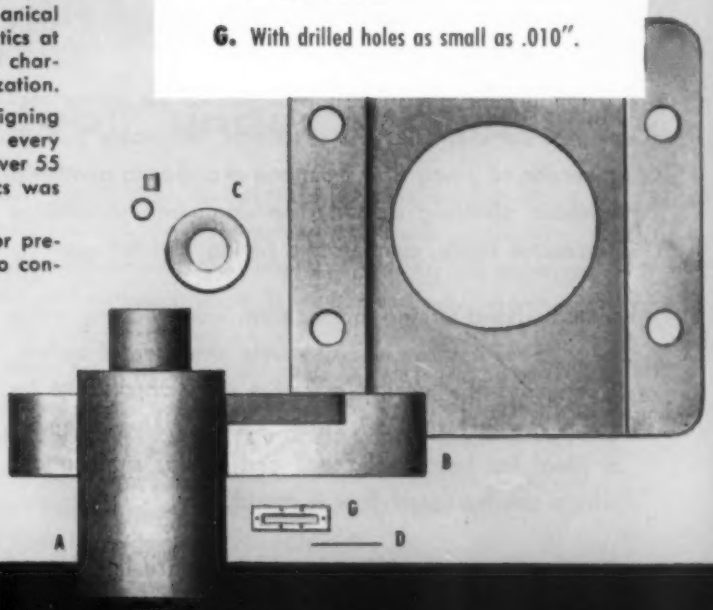
C. In flatnesses within light bands.

D. In thicknesses from .007" up.

E. In tubular form as small as .015" OD, .008" ID.

F. Threaded screws as small as 2-56 thread.

G. With drilled holes as small as .010".



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AMERICAN LAVA CORPORATION

CHATTANOOGA 5, TENN.
55TH YEAR OF CERAMIC LEADERSHIP

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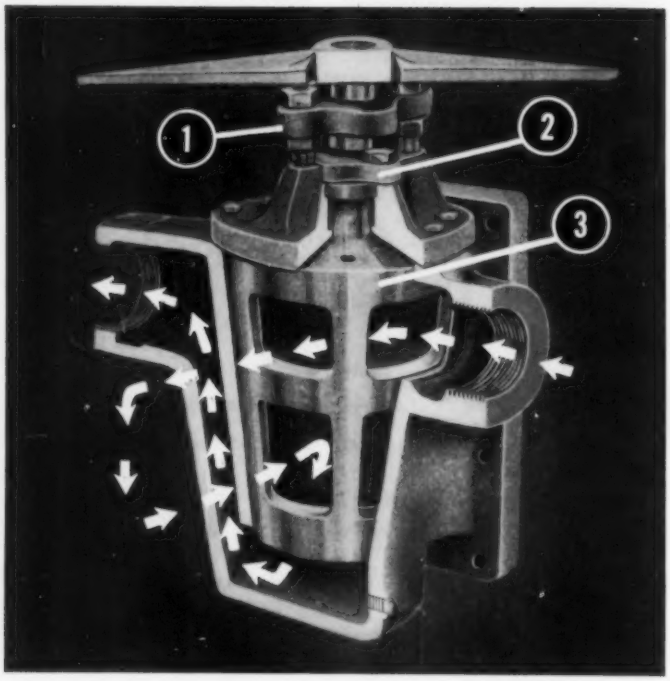


(1) Locking flange (2) Gland (3) Valve plug

NEW! Kraissl Class 72 Valve Simplifies Control of Non-Interrupted Flow

Originally designed and job-proven as the center section of our own Class 72 separator, this valve permits diversion of 2-way flow from one chamber to another—***without shutting down.*** The single-unit installation eliminates costly, cumbersome piping and fittings.

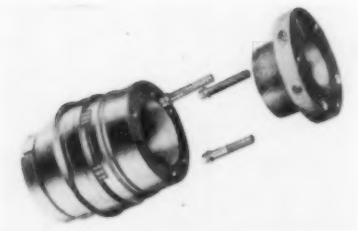
Simple, hand-turning of tapered, non-wedging valve plug re-routes flow into alternate chamber of system. Continuous-flow design of valve plug ***absolutely insures against shut-off.*** The Class 72 valve assembly is ideal for heat exchanger and similar applications where uninterrupted flow is mandatory.

Pressure ratings to 600 psig with standard line; Special valves for higher pressures.

Write for technical Bulletin A-1869

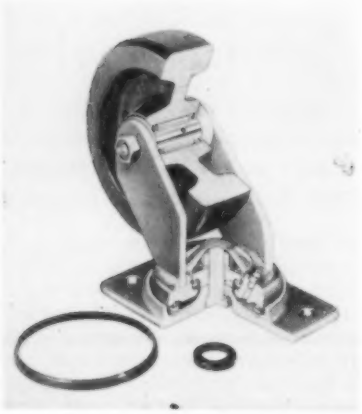
KRAISSL CO. Inc.

289 Williams Ave. Hackensack, N. J.



fit. Six size ranges from 22 to 150 hp at 1750 rpm are offered. Stock bushing-bore sizes begin at ½ in. and progress to 3½ in. by ⅛ in. increments. **Lovejoy Flexible Coupling Co., 4856 W. Lake St., Chicago 44.**

For more information—
Circle 33, inside back cover



Permanently Sealed Caster . . .

employs molded synthetic-rubber ring seals and a formed-steel, leak-proof retainer cup. Seal is inserted into a machined groove around the load race to provide a permanent lubricant seal for the load ball race without interference with swiveling action. In rigid and swivel models, almost every size and capacity. **Albion Industries, Inc., Albion, Mich.**

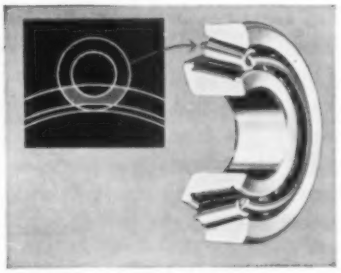
For more information—
Circle 34, inside back cover

Miniature, Heavy-duty, Four-throw Toggle Switch . . .

has capacity of 20-amp inductive at 28 v dc for 10,000 cycles. Size is 1.8 cu. in.; weight, 2 oz. This unit breaks inductive loads at high altitudes and operates actuators directly, eliminating relays. Designed to meet and exceed military specifications. It is a positive action switch, internally sealed with a silicone boot that keeps moisture and dust from the silver alloy contacts. Make-and-break wiping

(Continued on page 150)

Bearings "keep cool" under hot steel!



HIGHER FLANGE IMPROVES ROLLER ALIGNMENT

As shown by the gray area above, the higher flange provides a large two-zone contact area for the roller heads. This greatly reduces wear—practically eliminates "end play". Larger oil groove provides positive lubrication.

Watch it! Coming down the line—another half-formed slab of red-hot steel! And with it comes a supreme test of bearing excellence. Bower Bearings are equal to it—helping to keep this mill operating smoothly and continually despite heavy loads and extreme temperature. Whatever the job, there's a Bower Bearing engineered to perform just as dependably when the going is toughest. Rigid quality controls and basic bearing design refinements like those shown at the left have reduced Bower Bearing failure to a practical minimum. If your product uses bearings, specify Bower! There's a complete line of tapered, straight or journal roller bearings for every field of transportation and industry.

BOWER ROLLER BEARING DIVISION
FEDERAL-MOGUL-BOWER BEARINGS, INC. • DETROIT 14, MICHIGAN

BOWER ROLLER BEARINGS

Any similarity to a real-life company is purely intentional

How did the lathe builder get the worm to turn?

Henry Wadsworth Headstock had a dream. About a better turret lathe. It used worm gears in the drives.

He not only doodled it — he dood it. And he got a venturesome soul to try out a pilot model of his new Turnabout Lathe.

Then his troubles started to multiply — like ants at a picnic. For the worm gears conked out with a sickening regularity. There were 12 replacements in 24 weeks. (Three guesses what the big wheels thought of *that!*) Things certainly were in one heck of a mesh.

Then Henry heard of Ampco Metal, the special copper-base alloy. And he had a worm gear made out of *it*. The last we heard, the Ampco Metal gear had been running for a whole year and still showed no signs of wear.

Frankly, we're not surprised. Gear service — in fact, *any* wear application — is duck soup for Ampco Metal. It resists deformation under heavy loads and speeds — so tooth contours hold their original shape. There's no scoring, no galling — the worm has true bearing action against the worm wheel. Damping characteristics, plus fine mating properties, reduce the noise of the gear set.

The moral is obvious: Why gamble with guesses on gear life (or other critical parts), when it's so easy to be *sure*.

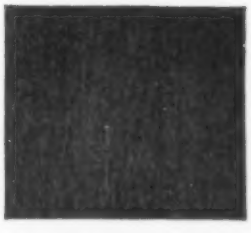
If you want to know more about Ampco Metal, call in your Ampco field engineer. Write for Bulletin 33. *Ampco Metal, Inc., Dept. PE-10, Milwaukee 46, Wisconsin. (West Coast Plant: Burbank, California)*

AMPCO® METAL *The metal without an equal* 6-2

Creative papers from the mills of Mosinee

And now . . . paper that finally defies mold

Only Mosinee — with its specialized research and manufacturing facilities — could bring you a paper with lasting, built-in resistance to fungus growth. NeverMold — *the paper that finally defies mold* — is ideal for scores of uses — packaging, structural fabrication, insulation, wherever protection against mildew or rot is desired. It's especially valuable for products that are shipped or stored in humid or tropical climates or for applications dealing with direct soil contact. Remember the name — NeverMold — one of many creative papers developed and perfected by the mills of Mosinee.



NeverMold paper—Unaffected after *four-week* soil burial test.

Untreated paper—Subjected to same test, disintegrated within *one week*.

FIND OUT how NeverMold paper can serve you. Fill out and mail this coupon.

MOSINEE PAPER MILLS CO., Dept. PEN-10, Mosinee, Wis.
Please send complete information file on NeverMold paper.

Name and Title.....

Firm Name.....

Address.....

City.....Zone.....State.....

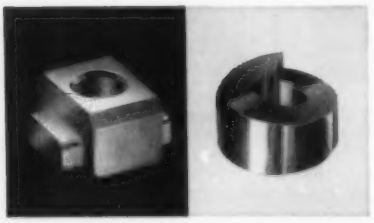
Mosinee
PAPER MILLS COMPANY
MOSINEE, WISCONSIN

A NEW
FREEDOM
IN BEARING
APPLICATIONS

Availability of Sintered Powdered Metal Bearings and machine parts from a fully competent and technically responsible source opens the way to improvements in mechanical products.

Bunting facilities for designing, engineering and manufacturing of Sintered Powdered Metal Bearings and parts are as comprehensive and responsible as the traditional Bunting competence in the field of Cast Bronze Bearings.

A competent group of Bunting Sales Engineers in the field and a soundly established Product Engineering Department put at your command comprehensive data and facts based on wide experience in the designing and use of Cast Bronze and Sintered Powdered Metal Bearings and parts.

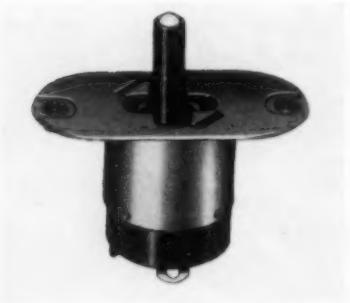


Write for catalogs and your copy of the new 24 page Bunting Engineering handbook of Sintered Powdered products and their composition, manufacture and application.

Bunting®

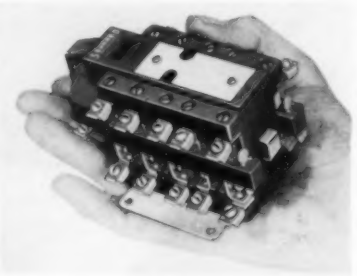
BUSHINGS, BEARINGS, BARS AND SPECIAL PARTS
OF CAST BRONZE AND POWDERED METAL

The Bunting Brass and Bronze Company • Toledo 1, Ohio • Branches in Principal Cities



contacts do not weld under high current and the unit withstands overloads several times its rated amperage. **Mason Electric Corp., 3839 Verdugo Rd., Los Angeles.**

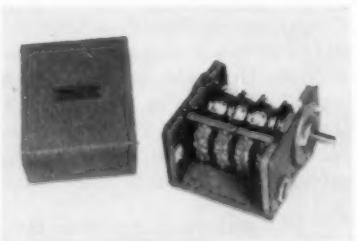
For more information—
Circle 35, inside back cover



Ten-contact Relay . . .

has max of six normally-open and four normally-closed, or eight normally-open and two normally-closed contacts. Measures 5 x 3 in.; also offered in four and six-contact sizes. All three sizes have identical mounting hole dimensions. **Square D Co., 4041 N. Richards St., Milwaukee 12.**

For more information—
Circle 36, inside back cover



Rotating Cam Limit Switch . . .

has independently adjusted split-type lobes, ball bearings, reversible shaft. One size lobe is all that is required. By adjusting one lobe with respect to the other a continuous range of open or closed circuits can be obtained from 360° to approximately 3°, without changing cam

(Continued on page 154)

NOW

for the first time

LOW COMPRESSION SET

Butyl "O" RINGS

NEW

Another LINEAR first . . . a new, low compression-set Butyl Compound for use in "O" Rings. LINEAR Butyl Compound 7806-70 is a seal material that withstands compression set at elevated temperatures without being permanently deformed or losing its resiliency and its value as a seal. Also, Butyl withstands the chemical actions of the non-flammable phosphate esters such as "Skydrol", "Pydraul", "Celluflex" and "Lindol".

YET, PROVEN

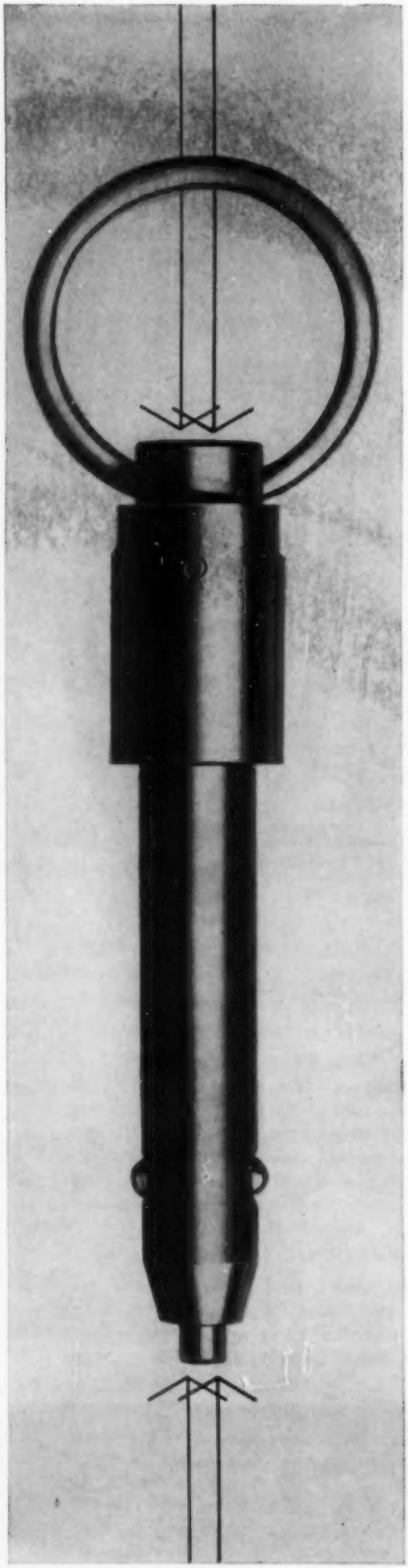
Exhaustive tests, under method "B" of the ASTM, show this new LINEAR compound develops only 30 to 40% compression set after 70 hours at 212°F, as compared to the usual 70 to 95% set experienced with previous Butyl compounds. This unusually good resistance to permanent deformation, combined with a tensile strength of 2000 psi and an elongation factor of 275%, make this material an outstanding one for all "O" Ring applications and other molded shapes where Butyl rubber's excellent qualities are desirable.

Whenever you have a seal problem that is tough to handle—look to LINEAR for an answer. Write, or ask the local representative for complete information on LINEAR's new Butyl Compound 7806-70—today.

"PERFECTION IN RUBBER"

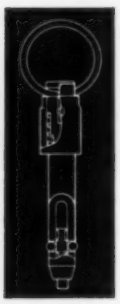
LINEAR

LINEAR, Inc., STATE ROAD & LEVICK ST., PHILA. 35, PA.



DOUBLE-ACTING "B" SERIES

PIP® SELF-LOCKING QUICK-RELEASE PINS



the pin that's designed for positive release...even under "over-load" or "bound" conditions!

Double-acting PIP Pins combine rugged strength and dependability with INSTANT INSERTION, AUTOMATIC SELF-SAFETYING...QUICK RELEASE! It's the most dependable self-locking quick-release pin you can use!

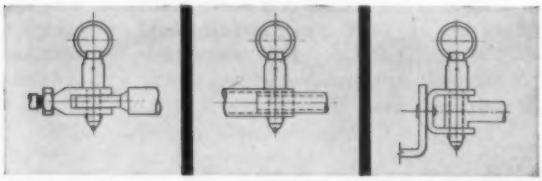
Now...eliminate nuts, bolts, cotter pins and other retaining devices and gain unlimited design freedom by using double-acting PIP Pins to fasten units that must be assembled and disassembled frequently. PIP Pins permit quick-change of mechanical units, speed assembly...reduce servicing costs.

Double-acting "B" Series PIP Pins have the special advantage of the exclusive PIP "drive-in"—"drive-out" feature...makes it easy to install or remove pin when misaligned holes or extra heavy loads cause "binding".

MEETS RIGID REQUIREMENTS

Double-acting PIP Pins are used by leading manufacturers of industrial, electronics, construction and materials handling equipment. Used by every major aircraft manufacturer. PIP Pins with "drive-in"—"drive-out" features are available in standard diameters to fit most nominal holes. "B" Series double-acting PIP Pins with continuous steel ring are particularly adaptable to remote release systems.

Let our Engineering Staff help you determine the correct solution to *your* quick-release fastening problem.

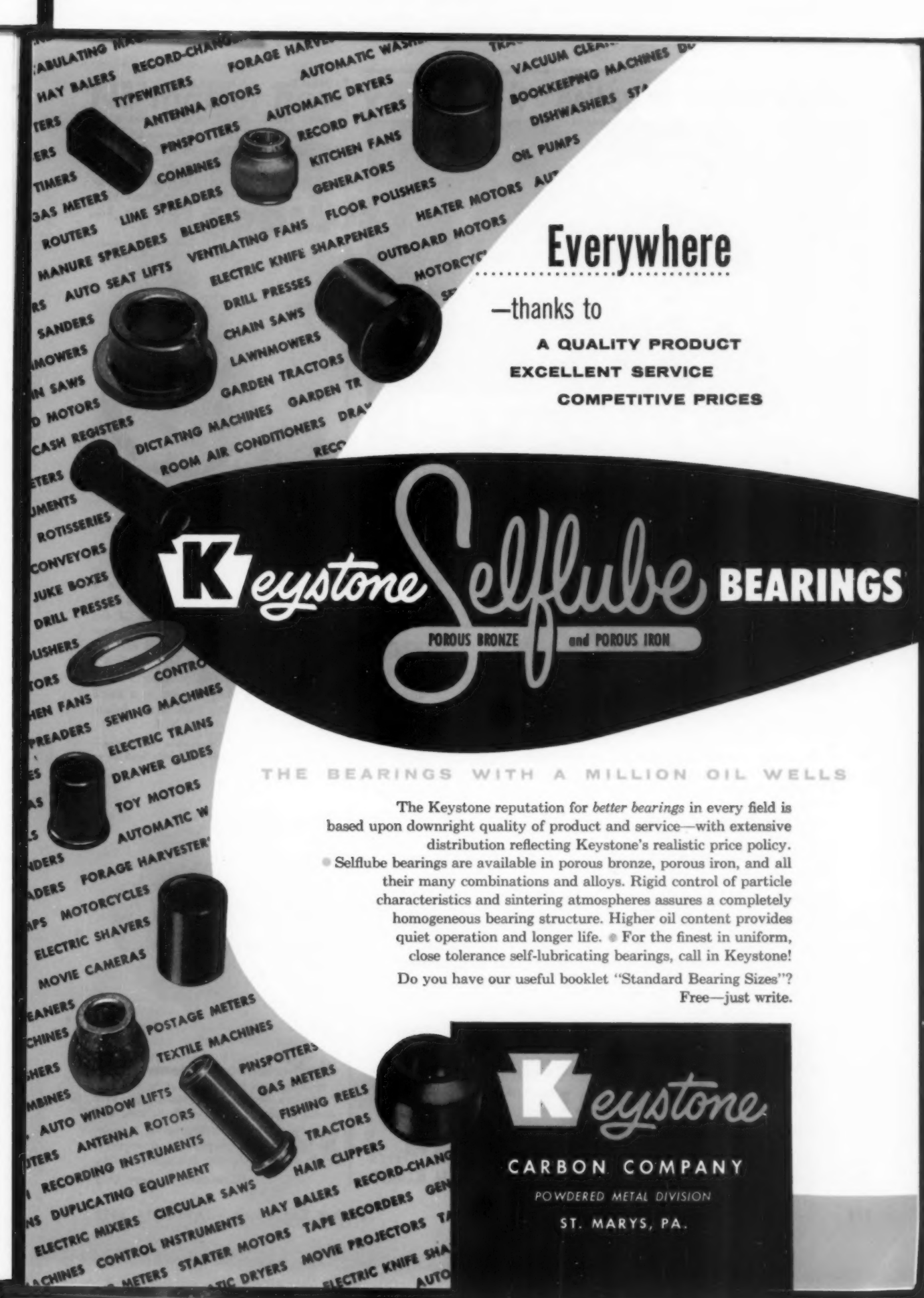


Clevis fitting Tube assembly Bracket assembly

DESIGN ENGINEERS—MANUFACTURERS: Write for your FREE copy of Brochure NO. ADI-5500. Contains specifications and technical data.

AVIATION DEVELOPMENTS INC.
210 S. VICTORY BLVD.
BURBANK, CALIFORNIA

Sales offices in principal cities
Manufacturers of PIP® Self-Locking Quick-Release Pins, Chobert® Rivets and Avdel Sheet Grippers.



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POROUS BRONZE and POROUS IRON

THE BEARINGS WITH A MILLION OIL WELLS

The Keystone reputation for *better bearings* in every field is based upon downright quality of product and service—with extensive distribution reflecting Keystone's realistic price policy. • Selflube bearings are available in porous bronze, porous iron, and all their many combinations and alloys. Rigid control of particle characteristics and sintering atmospheres assures a completely homogeneous bearing structure. Higher oil content provides quiet operation and longer life. • For the finest in uniform, close tolerance self-lubricating bearings, call in Keystone!

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Keystone

CARBON COMPANY

POWDERED METAL DIVISION

ST. MARYS, PA.

chain drives in action

add "muscle" to tough, dirty sewer cleaning jobs . . .

Now, with Flexible Seweroders up to 4000 feet of pipe can easily be cleaned in one day. And, at less than 2¢ per foot.

Silt, sludge, waste clog up sewers . . . make cleaning a rough job. Make it rough on the machine, too, causing starting shock and heavy drag loads. Yet these Seweroders steadily bore in, clean out, give years of dependable service.

Specified as standard equipment on all models, Cullman chains and sprockets push, pull, rotate the cleaning rods and drive the clutch mechanism. And make possible major improvements such as higher load capacities, longer service life and lower upkeep.

here's how chain drives can work for you...

On your products too, Cullman chains and sprockets can achieve similar advantages, help deliver top performance.

Next time you're faced with a power transmission problem write direct or call in a Cullman man. He'll be glad to assist you . . . and recommend the right chain for your job.

For the full story on the Cullman power transmission line — roller chains, sprockets and flexible couplings, write today for catalog No. 51, or see your local Cullman Distributor.

66572

cullman

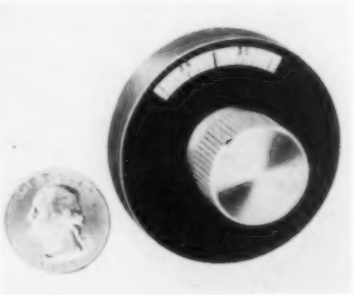
POWER TRANSMISSION ROLLER CHAINS AND SPROCKETS

REPRESENTATIVES AND DISTRIBUTORS IN ALL PRINCIPAL CITIES

CULLMAN WHEEL COMPANY, 1334 ALTGELD STREET, CHICAGO 14, ILLINOIS

lobes SPDT, switch contacts with a 15-amp rating at 115 v and 5 amp at 440 v. Available in NEMA types 1, 4, 7, and 12 enclosures with from two to 12 circuits. Optional features are double shaft extension and gear reductions. **Gemco Electric Co., 25685 W. Eight Mile Rd., Detroit 40.**

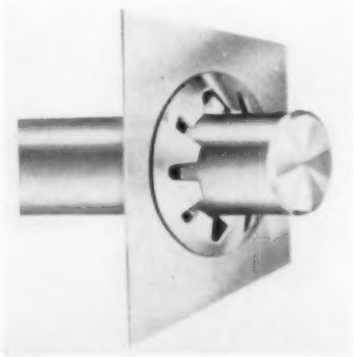
For more information—
Circle 37, inside back cover



Direct-reading, 10-turn Dial . . .

indicates tenths of each turn directly in numerals. Also, each tenth of a turn is subdivided into 10 parts giving a total of 1000 divisions for 10 turns of the knob. Housed in a dull black case that is 2 in. dia. Black numerals and lines are on a white ground. Drive ratio is 1:1 with counter-clockwise rotation increasing the reading. Dial mounts in a single hole and accepts any ¼-in. shaft. **Johanson Mfg. Corp., Boonton, N. J.**

For more information—
Circle 38, inside back cover



Shaft-retention Fasteners . . .

made of high carbon steel, slip over metal or plastic shafts, studs or rods, and lock in place with strong spring tension. No special shaft preparation is required. Pilot teeth guide the fastener onto the

(Continued on page 156)

No matter how you say it . . .

*TRANSLATION: CUTTING OIL

The performance and the brand are the same around the world

Other Outstanding Shell Industrial Lubricants

Shell Tellus Oil—for closed hydraulic systems

Shell Alvania Grease—multi-purpose industrial lubricant

Shell Turbo Oil—for utility, industrial & marine turbines

Shell Rimula Oil—for heavy-duty diesel engines

Shell Talona R Oil 40—anti-wear crankcase oil for diesel locomotives

Shell Dromus Oils, a quality line of soluble cutting oils, permit higher speeds and greater feeds while extending tool life. They have excellent wetting and cooling properties and are not sticky or greasy.

Dromus® Oils have the added advantage of being easy to mix in hot or cold, hard or soft water. They form emulsions which remain stable in practically any concentration required in the shop.

Today Dromus Oils are available to your customers abroad. You can be sure that they will enjoy the same efficient performance your domestic customers rely upon.

• • •

For more information, write Shell Oil Company, 50 West 50th Street, New York 20, N. Y., or 100 Bush Street, San Francisco 6, California.

SHELL DROMUS OILS

SHELL

Uses: For pressure lubrication lines, hydraulic and pneumatic systems, oil and fuel lines, chemical and food processing lines, vacuum system connections, etc.

Advantages: Handles high pressures at low cost. Long life under continuous flexing and vibration. Tough, abrasion resistant. Low minimum bend radius. Crush resistant—won't collapse. Inert to hydrocarbons, oils, greases, synthetic hydraulic fluids, most solvents and alkalis. Odorless, tasteless, non-toxic, fungus resistant. Wide service temperature range. Applicable to standard flare and flareless fittings. Easily cut, flared, installed around existing equipment, requiring no pre-bending, flexible couplings or intermediate fittings.

Product of U.S.G's new, ultra-modern Nylon-Teflon Extrusion Plant—new and exclusive techniques and facilities.

Write for further information.

United States Gasket Company
Camden 1, New Jersey

United States Gasket *Plastics Division*
OF THE GARLOCK PACKING COMPANY

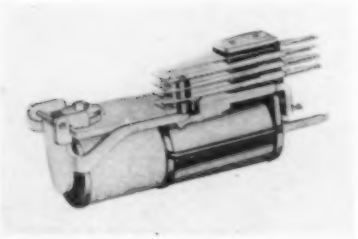
shaft. Fastener is cone-shaped and has an ID slightly smaller than the shaft. Range of sizes carried in stock. **Fastex Div., Illinois Tool Works, 195 Algonquin Rd., Des Plaines, Ill.**

For more information—
Circle 39, inside back cover

Hand Vibrometer . . .

measures amplitude and frequency of machinery vibration, and makes permanent records on a continuous paper chart. External adjustment selects magnification ratios of 40:1; 20:1; 10:1; or 5:1. No battery or outside power source is required. A carbon-shod, ball-bearing probe is provided for contacting the surface of rotating shafts. **Vibroscope Co., P.O. Box 97, Glenford, N. Y.**

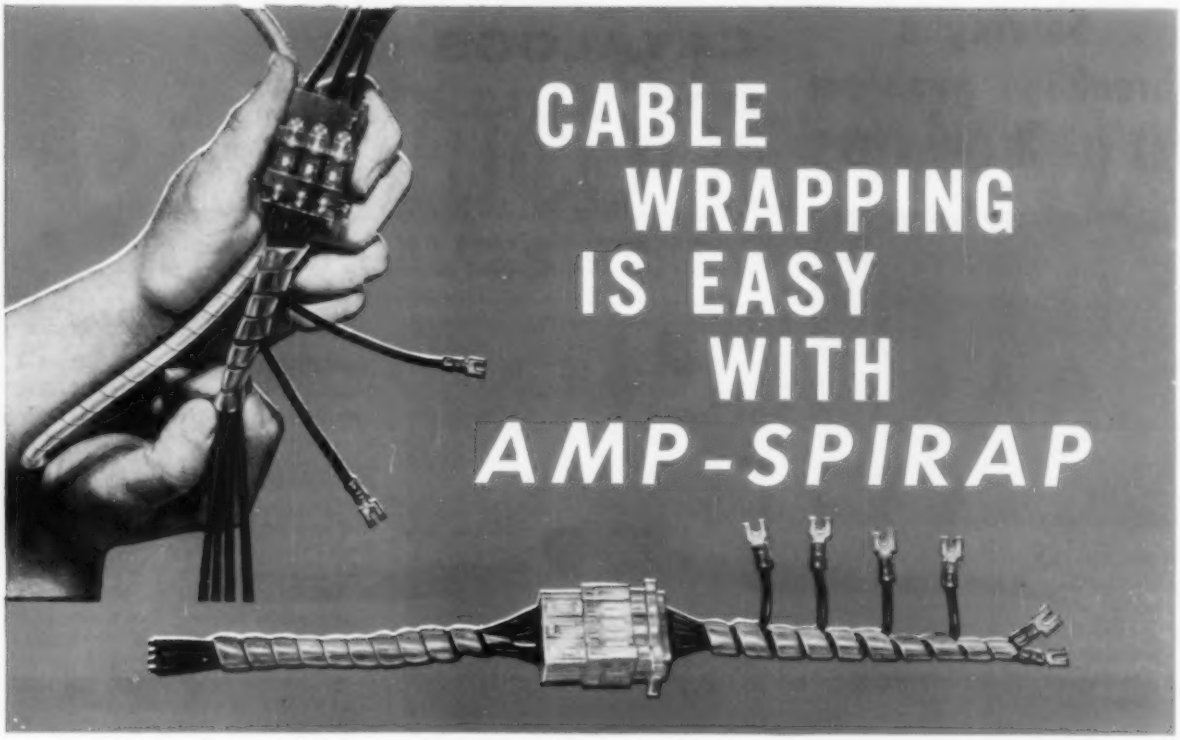
For more information—
Circle 40, inside back cover



High-Speed Telephone Relay . . .

has contact combinations to 10PDT. Contacts are rated for 3-amp, 150-w ac, noninductive load. Can be supplied with: copper head for delayed attract to 0.1 sec. depending upon spring assembly and coil power; copper heel for delayed release to 0.4 sec with small spring assembly and power coil. Flexible relay is said to operate at high speeds for long continuous service. Equal to, and interchangeable with, existing telephone relays. **Guardian Electric Mfg. Co., 1621 W. Walnut St., Chicago 12.**

For more information—
Circle 41, inside back cover



The development and production of the finest quality solderless terminals for your electrical circuitry requirements is AMP's primary objective. We also constantly search for allied products and application techniques that will speed, simplify, and obsolete present time-consuming sub-assembly operations. *AMP-SPIRAP* and its application technique stems from such constant searching activity.

AMP-SPIRAP is a unique, spirally-cut plastic wrapping that . . .

- eliminates tedious cable lacing, insulation damage, and pulling of wires through spaghetti tubing
- is quickly applied to wire bundles of any size up to 3½ inches diameter
- permits individual wires to be entered or led out at any point
- is quickly unwound to allow wires to be added, removed, or relocated—thereby eliminating the necessity for cutting into the cable bundle after assembly
- holds wires together tightly, but permits flexibility for forming cable
- provides mechanical protection over entire length of cable

When required for your maintenance and repair needs, *AMP-SPIRAP* is available in the U.S.A. through American Pamcor Inc.

api AMERICAN PAMCOR INC.

Additional information about *AMP-SPIRAP* and its application versatility is available on request. *SEND FOR YOUR FREE SAMPLE TODAY.*

AMP INCORPORATED

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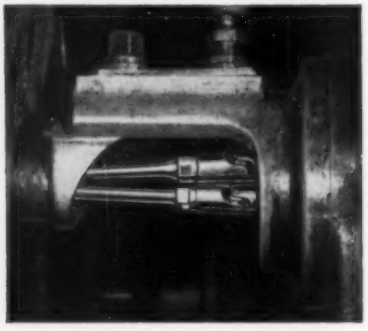
Distributor in Japan: Oriental Terminal Products Co., Ltd., Tokyo, Japan

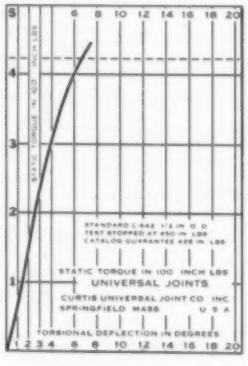
Solving a breakage problem AT CLOSE QUARTERS



The manufacturer of this button-drilling machine had a tough problem: the universal joints on these parallel shafts carried such a torque load there were frequent complaints of breakage . . . yet the close centers prohibited use of a larger joint.

THE SOLUTION was a Curtis Universal Joint of the same size.

Torque Curve ½" Curtis Universal Joint


STATIC TORQUE IN 100 INCH LBS
UNIVERSAL JOINTS
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SPRINGFIELD MASS U S A
TORSIONAL DEFLECTION IN DEGREES

This is only one of many problems solved by Curtis Joints — size for size the strongest universal joints designed for industry. Selected materials, precision engineering, and over 30 years' experience manufacturing universal joints make them that way.

14 SIZES ALWAYS IN STOCK —
3/8" to 4" O.D. (6" joints on special order)

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CATALOGS and BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 172.

COMMERCIAL AND INDUSTRIAL UNIT HEATERS—Booklet B-1523, 26 pp. Describes construction and application of new line. With tables, wiring diagrams, and dimensional drawings. Westinghouse Sturtevant Div., Dept. T-333, 200 Readville St., Hyde Park, Boston 36.

Circle 42, inside back cover

LIGHT SWITCH—Data Sheet 135, 1 p. Dimensional drawings, mounting and wiring data, and electrical ratings of silent-operating switches. Includes net prices. Micro Switch Div., Minneapolis-Honeywell Regulator Co., Freeport, Ill.

Circle 43, inside back cover

HIGH - STRENGTH BONDING AGENTS—Brochure, 4 pp. Describes general properties of adhesives and plastic alloys based on an epoxy formulation. A detailed chart helps select the proper bonding product. H. B. Fuller Co., 255 Eagle St., St. Paul, Minn.

Circle 44, inside back cover

LAMPHOLDERS AND INDICATOR LIGHTS—Check chart, 1 p. Many lampholders and indicating lights for military applications, with corresponding catalog numbers for each. Drake Mfg. Co., 1711 W. Hubbard St., Chicago 22.

Circle 45, inside back cover

GLASS-TO-METAL AN CONNECTORS—Catalog 657C, 16 pp. Guide for selecting and specifying for military and commercial applications. Contains photos and dimensional drawings of shell sizes and insert configurations for aircraft, communications, electronic controls and instrument applications. Hermetic Seal Corp., 29 S. 6th St., Newark 7, N. J.

Circle 46, inside back cover

TIME RATE INDICATOR—Bulletin 501A-B, 4 pp. Discusses applications of the 10-mc unit. Explains features, functions and advantages as used in various types of electronic circuits. Laboratory for Electronics, Inc., 75 Pitts St., Boston 14.

Circle 47, inside back cover

CRYSTALLINE POLYETHYLENES—Booklet 100, 12 pp. Concerns thermal embrittlement of low-pressure polyethylenes. Paper was originally presented at the AIEE winter meeting. With photos, curves, graphs. Bakelite Co., Div. of Union Carbide Corp., 260 Madison Ave., New York 16.

Circle 49, inside back cover

STAINLESS STEEL FINISHING—Manual, 18 pp. Correct approach to actual finishing is presented in this catalog. Explains requirements peculiar to stainless steel finishing and how to meet them. An equipment section lists the recommended equipment for finishing. One section gives tips for better finishing. R. G. Haskins Co., 2651 W. Harrison St., Chicago 12.

Circle 49, inside back cover

CONVERTERS—Catalog 557, 20 pp. Illustrated listings of new line of dc to ac converters, including special models for railroad, marine and industrial service. Includes performance charts, dimensional diagrams, selector chart for tape recorder applications, and installation instructions. Carter Motor Co., 2711-A W. George St., Chicago.

Circle 50, inside back cover

VALVES AND CYLINDERS—Folder, 4 pp. Illustrates the complete line. With cross-sections, photographs and line drawings. Descriptions of the line are included. Rivett, Inc., Brighton 35, Boston.

Circle 51, inside back cover

PURGER—Bulletin PE-700, 2 pp. Specifications of purger designed for ammonia systems. Illustrated with operational drawing. Gives details of function, advantages, operation, equipment and prices. A graph on the reverse side gives densities of air and ammonia in various mixtures at various total pressures. J. E. Watkins Co., 307 Lake St., Maywood, Ill.

Circle 52, inside back cover

WHITEPRINTER—Bulletin 57S2, 4 pp. Information on 44-in. dry-process whiteprinter. P & H Sales Corp., 5640 N. Western Ave., Chicago 45.

Circle 53, inside back cover

ELECTRONIC BREADBOARD EQUIPMENT—Catalog, 4 pp. Gives specification data and dimensional drawings on magnetic clutches, clutch brakes, brake clutches, gear heads, speed reducers, differentials and brakes. Sterling Precision

(Continued on page 161)

DOW CORNING CORPORATION

Silicone News

FOR DESIGN ENGINEERS No. 43

New Silicone-Teflon Tape Withstands Acids, Cuts Packaging Costs

A new pressure-sensitive tape with exceptional chemical and thermal stability is now available from Minnesota Mining. Made from "Teflon" coated with a Dow Corning silicone adhesive, the tape readily withstands corrosive chemicals that deteriorate ordinary tapes.

Cap liners die-cut from this new type "Scotch" brand tape have already enabled Merck & Co., Inc., to greatly simplify their method of sealing bottles containing trichloroacetic acid. The acid is so corrosive that the bottles formerly were closed with ground glass stoppers held in place by paper caps fastened down with string and adhesive.

By employing the new silicone adhesive-coated tape, Merck packaging men have found it practical to use ordinary screw-on bottle tops. Small die-cut sections of the tape fitted inside the caps prevent

(*Cont. Pg. 2*)

SILICONE RUBBER ASSURES RELIABILITY OF ELECTRONIC "PACKAGES" ON B-58

In reaching for new plateaus of performance and reliability, designers are getting an assist from Silastic*, the Dow Corning silicone rubber. Typical is the extensive use of Silastic to insulate and protect the delicate electronic "packages" in the fire control system on Convair's B-58 Hustler.

In developing the "packages," heat was a major problem encountered by the designers—the Electronics and Avionics Division of Emerson Electric Manufacturing Company. Certain rubber parts touch miniature tubes that operate at 350 F. Other rubber components, such as seals, cable grommets and clamps, are totally enclosed in packages where even the "cooling" air gets hot. Extreme cold is another problem. When the fire control system is shut off during high altitude flight, temperatures may drop to 65 below zero.

But Silastic easily withstands both extremes of temperature and physical punishment. It stays rubbery from —130 to 500 F, has excellent dielectric strength, moisture resistance and long life. That's why Emerson specified Silastic, and that's why more and more engineers are specifying Silastic for maximum serviceability and minimum maintenance cost in applications ranging from aircraft seals to industrial heaters, from traction motors to home appliances.

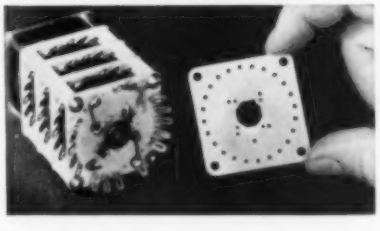
*T.M. REG. U.S. PAT. OFF. No. 436

New Rotary Switches More Reliable With Silicone-Glass Laminates

Combining unique dielectric and physical properties, silicone-glass laminates can be used to improve the performance of electrical and electronic devices involving extreme heat or moisture. An unusually good illustration is provided by Shallcross Manufacturing Company, Collingdale, Pennsylvania.

Shallcross' new line of 24-position electrical rotary switches features decks stamped from glass cloth laminate bonded with a Dow Corning silicone resin. The heat-stable silicone-glass decks keep terminals locked securely in place despite heat of soldering. More important, the silicone-glass construction of these 1500 V, 1 to 6 deck rotary switches assures reliable operation in hot, cold or humid climates where other insulating materials would fail.

(*Cont. Pg. 2*)



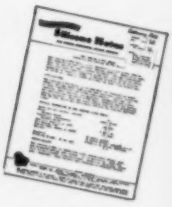
FOR DATA RELATING TO THESE ARTICLES, CIRCLE REFERENCE NUMBER IN COUPON ON NEXT PAGE

MORE

DOW CORNING CORPORATION

Silicone News

DOW CORNING PUBLICATIONS ON NEW DEVELOPMENTS AND TECHNICAL DATA . . . .



Pressure-sensitive silicone tapes—that stick to wet or dry surfaces; form good bonds; have high dielectric strength; repel moisture; are not affected by corrosive chemicals—are described in a new folder designed to help you choose the tape best suited to your application. *No. 440*

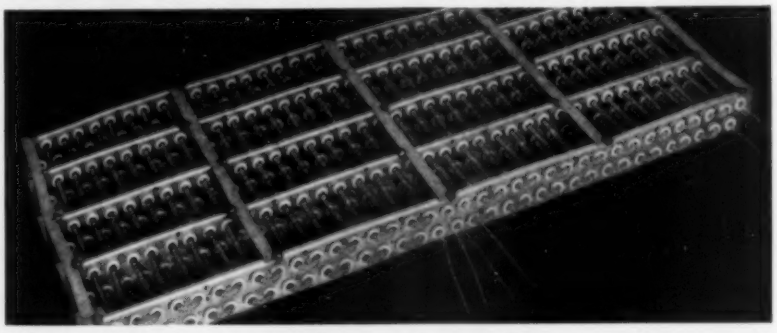
Twelve page, fact-filled reference to Dow Corning Silicones describes the silicone products of interest to most industries. Containing useful data and information, this Guide to Silicone Products is designed expressly to help you enjoy the advantages, profits, and savings made possible through imaginative use of these versatile engineering materials. *No. 441*

Silastic — in mechanical applications — increases life and serviceability of original equipment; reduces maintenance and downtime. A completely new brochure gives properties and cites applications and case histories to help you use this versatile silicone rubber to best advantage in your application. *No. 442*

Silicone Coatings for Metal Products. An article reprint from MATERIALS AND METHODS provides a comprehensive review of current uses for all types of silicone finishes now available. Includes information on coverage, costs, and methods of application. A valuable aid in selecting the most suitable type of silicone finish for any particular application. *No. 443*

Silicone Materials in Appliance Design, a recent article in ELECTRICAL MANUFACTURING, lists a variety of applications for several different silicones in appliances, describes how silicones have made possible design changes heretofore impractical, and how they extend service life and dependability. *No. 444*

Parts and components made with Dow Corning Silicone Molding Compounds are lightweight, show excellent resistance to heat, and have good structural and electrical properties. Used as brush holders, collector rings, terminal boards, multiple lead connectors, heat dams for turbine driven alternator bearings, and aircraft brake shoe backing. *No. 445*



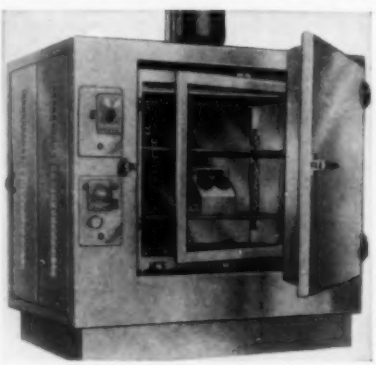
Silicone Fluids on Insulators Stops Shorts and Grounds

Imaginative use of a silicone fluid has enabled Blue M Electric Company, Blue Island, Ill., to engineer faster response and more accurate heat control into its laboratory humidity cabinets.

Moisture condensation on the steatite grommets that support the resistance wire heating elements was always a problem in these cabinets. Moisture caused such a low resistance to ground that the elements had to be sheathed. This, of course, reduced the heat-up speed and made it more difficult to maintain accurate temperatures in the cabinets.

Blue M now controls the condensation problem by simply coating the ceramic insulators with Dow Corning 200 Fluid. The resulting water-repellent silicone surface is so successful in preventing the formation of conducting moisture films that the treated insulators withstand 1000 volts to ground even with droplets of water on their surface. As a result, Blue M has been able to change to faster, more accurate "open" elements without fear of grounds or shorts.

Blue M uses a 2% solution of Dow Corning 200 Fluid in carbon tetrachloride. The insulators are dipped into this solution and baked for one hour at 575 F. *No. 438*



NEW ROTARY SWITCHES *(Cont.)*

According to Shallcross, silicone-glass laminate was chosen because of these outstanding properties:

1. Low moisture absorption.
2. Thermal stability which not only permits service in varying climates, but prevents terminals loosening during soldering.
3. Good surface resistivity.
4. Low dielectric loss for increased RF efficiency.

The silicone-glass laminate used in these switches is "Phenolite G-7-830," produced and sold by National Vulcanized Fibre Company. National fabricates the plates maintaining a tolerance of ±.005 inch in the punched holes. *No. 437*

ACID RESISTANT TAPE *(Cont.)*

contact between metal and acid, thus eliminating the need for glass stoppers.

In addition to facilitating handling and shipping, the new tape has reduced material and labor requirements sufficiently to actually cut overall packaging costs in half for Merck & Co. *No. 439*

Dow Corning Corporation, Dept. 8621, Midland, Michigan

Please send me: 436 437 438 439 440 441 442 443 444 445

NAME _____

TITLE _____

COMPANY _____

STREET _____

CITY _____ ZONE ____ STATE _____

SILICONE NEWS is published for product design and development engineers by

first in silicones

Dow Corning CORPORATION

MIDLAND, MICHIGAN

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Corp., Instrument Div., 34-17 Lawrence St., Flushing 54, N. Y.

Circle 54, inside back cover

SWITCHES—Data Sheets 129, 134; 2 pp each. Catalog listings, specifications and dimensional drawings for double-duty explosion-proof and three-position toggle switches. Micro Switch Div., Minneapolis-Honeywell Regulator Co., Freeport, Ill.

Circle 55, inside back cover

CLUTCHES—Bulletins PSC-100, OB-10, SP-20, 8 pp. PSC-100 explains advantages of the clutch, illustrates methods of actuation and describes typical installations. Details of applications, operation and construction of standard ball bearing over-running clutches and standard sleeve and plain bearing over-running clutches are given. mounting arrangements are explained. With full tables of dimensional and engineering data and cross-sectional drawings. Curtiss-Wright Corp., Marquette Div., 1145 Galewood Dr., Cleveland 10.

Circle 56, inside back cover

AUTOMATIC VARIABLE-SPEED PULLEYS—Bulletin C357, 4 pp. Operational, specification, and dimensional data on pulleys for fractional-hp machinery. With dimensional and cross-section drawings. Includes speed range tables and information on how to select the proper pulley. Equipment Engineering Co., 2853 Columbus Ave., Minneapolis.

Circle 57, iside back cover

PVC TUBING—Leaflet, 1 p. Reinforced plastic PVC tubing is illustrated and described with specification data and characteristics. Newage International, Inc., 222 York St., Jenkintown, Penn.

Circle 58, inside back cover

SPECIALIZED INSTRUMENTATION—Technical Newsletter, 6 pp. First issue of new periodical. Deals with a new tool for moisture analysis. Explains nuclear magnetic resonance and describes in detail how the tool operates. Illustrations include block diagrams, absorption and calibration curves, chart recording, and photos. With detailed specifications. Schlumberger Well Surveying Corp., Ridgefield, Conn.

Circle 59, inside back cover

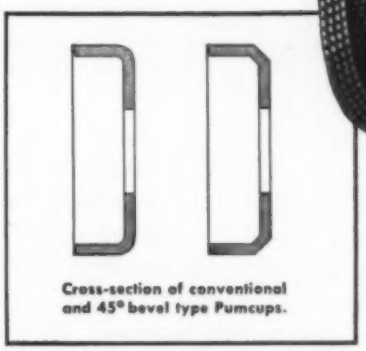
REDUCER AND NON-REDUCER MOTORS—Bulletin, 12 pp. Lists and describes 265 standard motors of various types and sizes. Illustrated with photos and dimensional drawings. Bodine Electric Co., 2254 W. Ohio St., Chicago 12.

Circle 60, inside back cover

SILICONE RUBBER—Brochure 9-106, 6 pp. Details physical properties and how

(Continued on page 164)

2-way gain with Pumcups



Cross-section of conventional and 45° bevel type Pumcups.

Darcova Pumcups are available in various types and textures, in a complete range of sizes, to provide unequalled efficiency and long life in reciprocating pumps, air or hydraulic mechanisms.

★ prolonged high efficiency
★ less maintenance

TODAY hundreds of companies using hydraulic controls, air cylinders or reciprocating pumps are *standardizing* on Darcova Pumcups for piston packing, because they eliminate fluid slippage, costly down-time and maintenance.

Darcova Pumcups make the *most* of the cup packing principle. And, they are made in a complete range of sizes, types and texture-engineered compositions for various pressure-temperature-fluid conditions. Pumcups hold peak efficiency for the life of the cups and outlast other packing as much as 3 to 1.

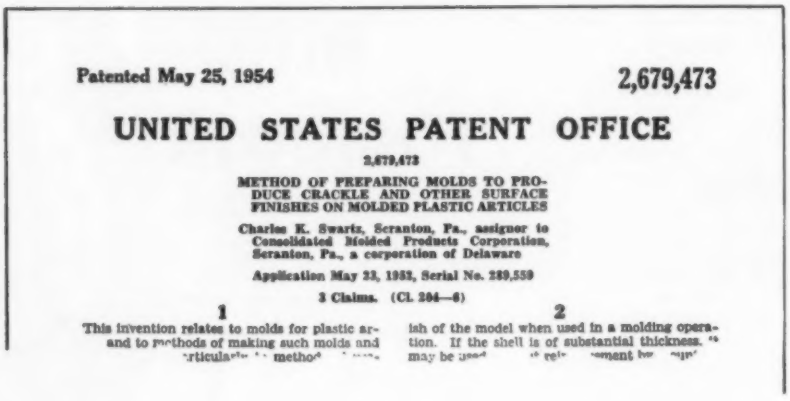
Why not check these claims right in your own plant? Meanwhile get *all* the facts. Just send for Pumcup Bulletin No. 5503.

DARLING VALVE & MANUFACTURING CO.
Williamsport 25, Pa.

DARCOVA — THE ORIGINAL COMPOSITION CUP

TRADE MARK PUMCUPS

THIS IS ANOTHER **CONSOLIDATED** "EXTRA":



Patented May 25, 1954 2,679,473

UNITED STATES PATENT OFFICE

2,679,473

METHOD OF PREPARING MOLDS TO PRODUCE CRACKLE AND OTHER SURFACE FINISHES ON MOLDED PLASTIC ARTICLES

Charles K. Swartz, Scranton, Pa., assignor to Consolidated Molded Products Corporation, Scranton, Pa., a corporation of Delaware

Application May 23, 1953, Serial No. 289,559

3 Claims. (Cl. 204—6)

1

This invention relates to molds for plastic ar- and to methods of making such molds and articulate... method...

2

ish of the model when used in a molding operation. If the shell is of substantial thickness, ... may be used ... reinforcement ...

Now your machine housings in plastics can have "Crackle" and other beautiful finishes to match your metal components. Consolidated's distinctive process adds beauty and individuality to cabinets for typewriters, business machines and electronic equipment. As with all other Consolidated patents, this process is available free to our customers. We'll be glad to show you how these unusual textures by Consolidated can increase your sales.

There are many good reliable molders of plastics in the field today. We at Consolidated pride ourselves on being included among them. We have always offered our customers certain "extras"—ingenious mold design, new processing techniques, and tested methods of quality and cost control.

If you are already a Consolidated customer, you know our way of doing business; you know that we are sincerely interested in the success of your product. You've come to expect those "plus" services that can mean so much to you.

But if you are not yet acquainted with Consolidated, why don't you get in touch with us. Let us help you give your product those extra touches that produce extra sales.

YOUR BLUE PRINT IN PLASTICS CMP

CONSOLIDATED MOLDED PRODUCTS CORPORATION

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Harvey Aluminum Impact Extrusions

Many engineers and designers are overlooking the exclusive advantages of aluminum impact extrusions. This advanced metalworking operation offers design flexibility; versatility of alloys; draft free, close tolerance parts requiring minimum machining; smooth surfaces; and significant savings in man hours, machining, and material.

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Typical applications of Harvey Impact Extrusions are illustrated below. Harvey Impacts have a smooth surface and require no machine finishing for most commercial, ordnance, airframe, and missile applications. Harvey's integrated services provide an economical, quality product that meets all specifications of high strength, light weight, resistance to corrosion and heat, critical tolerances in wall thickness, maximum heat conductivity, and low unit cost.

Harvey Aluminum leads in impact extrusions

Harvey pioneered in the impact extruding of intricate configurations. This experienced leadership, plus technical know-how and the most advanced facilities, are available for your own specialized design requirements. The integrated Harvey engineering team of research, design, metallurgy, and quality control will expedite your product from drawing board to finished product quickly, efficiently, economically.

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PISTON made with flat top or dome. Applications for aluminum pistons range from light horsepower engines to automotive and aircraft motors. Highest physical properties, surpassing any forging or casting. Metallurgical characteristics of Harvey alloys insure highest fatigue strength, excellent grain structure, best heat dissipation.

LANDING GEAR COMPONENT provides highest physical properties, greatly reducing material and machining costs. The impact, obtainable in various lengths, is made from aluminum alloys which assure optimum internal grain structure. This impacted piston replaces costly method of hogging out bar stock or machining a forging. Diameters of barrel are held to close tolerance dimensions with superior surface finish.

TUBE SUPPORT provides solid head on one end of tube. This unique aluminum impact extrusion offers the most economical fabrication method for a support tube application without sacrificing high physical properties. Aluminum impact eliminates considerable machining, offers maximum design versatility. Available in a range of sizes and alloys.

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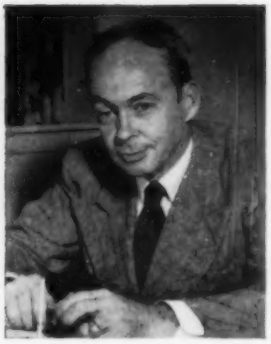
Harvey is a leading independent producer of quality aluminum products in all alloys and sizes: Rod and bar, pipe, tube, hollow sections, press forgings, forging stock, impact extrusions, structurals, special shapes, extrusions, screw machine products and other aluminum products. Harvey is also producing similar items in titanium and steel.

MICRO-BEARING ABSTRACTS

by **A. N. DANIELS**, *President*
New Hampshire Ball Bearings, Inc.



CONTACT ANGLE

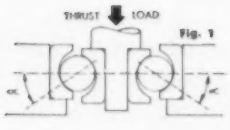


Fig. 1

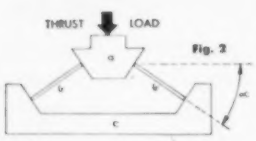


Fig. 2

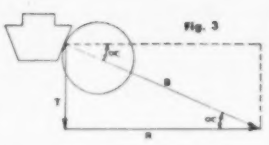


Fig. 3

Contact angle is the angle between a plane perpendicular to the bearing axis and a line connecting the two points on a given ball where the ball makes contact with the raceways when the bearing is subjected to a pure thrust load. In *Fig. 1*, the contact angle is represented by angle α. The significance of the contact angle is revealed by an examination of the forces present in a thrust loaded bearing.

In *Fig. 2*, a simplified version of *Fig. 1*, the shaft and inner ring combination are represented by the plug *a*, the "working diameters" of the balls and represented by the rodlike members at *b*, and the outer ring is represented by the tapered cup *c*.

The contact angle is α. This diagram represents a three-dimensional structure with as many equally spaced rods, *b*, as there are balls in the bearing.

The primary concern in design is the amount of compressive force to which rod *b* is subject, which is the force with which a given ball is pressed against the raceways. This force can be calculated by constructing a parallelogram of forces as shown in *Fig. 3*.

The sides T and R, are vector quantities, and diagonal B is the vector sum of T and R. Furthermore, the vector sum of the thrust components on all the balls equals the total thrust load on the bearing. The vector sum of the radial components on all the balls is zero. Vector B, the force actually felt by the raceways and balls, compared to vector T, the thrust component, varies significantly with changes in the size of the contact angle and is directly proportional to the thrust load component and inversely proportional to the sine of the contact angle.

Example I:

A bearing is carrying a pure thrust load of 21 pounds. Assuming seven balls in the bearing, each ball will have an axial load component of three pounds, since a thrust load is shared equally by all the balls. While the axial component on each ball is only three pounds, the actual compressive force, or squeeze, felt by the ball and raceways is considerably greater than this value.

With a contact angle of five degrees:

$$B = \frac{T}{\sin \alpha} = \frac{3 \text{ lbs.}}{\sin 5^\circ} = 34.5 \text{ lbs.}$$

Thus we see that with a five-degree contact angle the actual load felt by each individual ball is actually considerably greater than the total 21 pound thrust load on the bearing.

Example II:

Using the thrust conditions in Example 1, the contact angle is increased to 20 degrees, by selecting a bearing with a larger value of radial play.

$$B = \frac{3 \text{ pounds}}{\sin 20^\circ} = 8.78 \text{ pounds}$$

A 15 degree increase in contact angle produced a 74.5% reduction in ball-to-raceway contact stress. This relationship should be noted by anyone who writes bearing specifications. The operational qualities of the bearing, such as low running and starting torque and bearing life, are a function of the ball-to-raceway contact stress. Thus the contact angle is highly significant.

It is not necessary for a bearing user to calculate or specify the contact angle desired. It is only necessary to remember that low values of contact angle are associated with low radial play, and high values of contact angle are associated with high radial play. In addition to the above considerations, gyratory forces become extremely important factors in determining optimum contact angle in high speed applications.

A more complete discussion of contact angle is found in our design handbook.

DESIGNERS HANDBOOK OFFERED *FREE* TO ENGINEERS

If you work with miniature bearings, you'll find this new, 70-page authoritative publication a great help in solving problems in designing instruments or small electro-mechanical assemblies.

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Catalogs and Bulletins.....continued

the material is used in mechanical parts. Resistance to heat, cold, weathering, ozone, moisture, oils and chemicals are discussed, and illustrated with graphs, tables and on-the-job examples. Dow Corning Corp., Midland, Mich.

Circle 61, inside back cover

MOLDING COMPOUNDS—Bulletin, 4 pp. Illustrates applications of reinforced compounds. Includes a section on selecting proper resin and filler. Discusses properties of the plastic compound. Fiberite Corp., 512 W. 4th St., Winona, Minn.

Circle 62, inside back cover

SILICONE-BASED LUBRICANT—Brochure 6-209, 4 pp. Describes No. 44 grease and its applications. Table gives property and performance data. Typical applications are illustrated and discussed. Dow Corning Corp., Midland, Mich.

Circle 63, inside back cover

AUTOMATIC VARIABLE - SPEED PULLEYS—Bulletin, 8 pp. Cutaway drawings, performance curves, dimensional drawings and specification charts illustrate this bulletin on automatic pulleys for infinitely variable speeds with constant-speed motors. Gives operating principles and exclusive features. Equipment Engineering Co., 2853 Columbus Ave., Minneapolis.

Circle 64, inside back cover

METAL STAMPINGS—Brochure, 8 pp. Facts about a small-lot stamping service, illustrated with typical examples of manufactured parts. Cost data is included. Dayton Rogers Mfg. Co., Minneapolis 7.

Circle 65, inside back cover

PRECISION STRIP—Catalog, 12 pp. Covers beryllium copper, chromium copper, phosphor bronze, nickel, silver, brass, stainless and nickel-iron strip rolled to close tolerances and thin gages. Tabular material presents availability, mill limits, applicable specifications and complete property data. Penn Precision Products, Inc., 501 Crescent Ave., Reading, Penn.

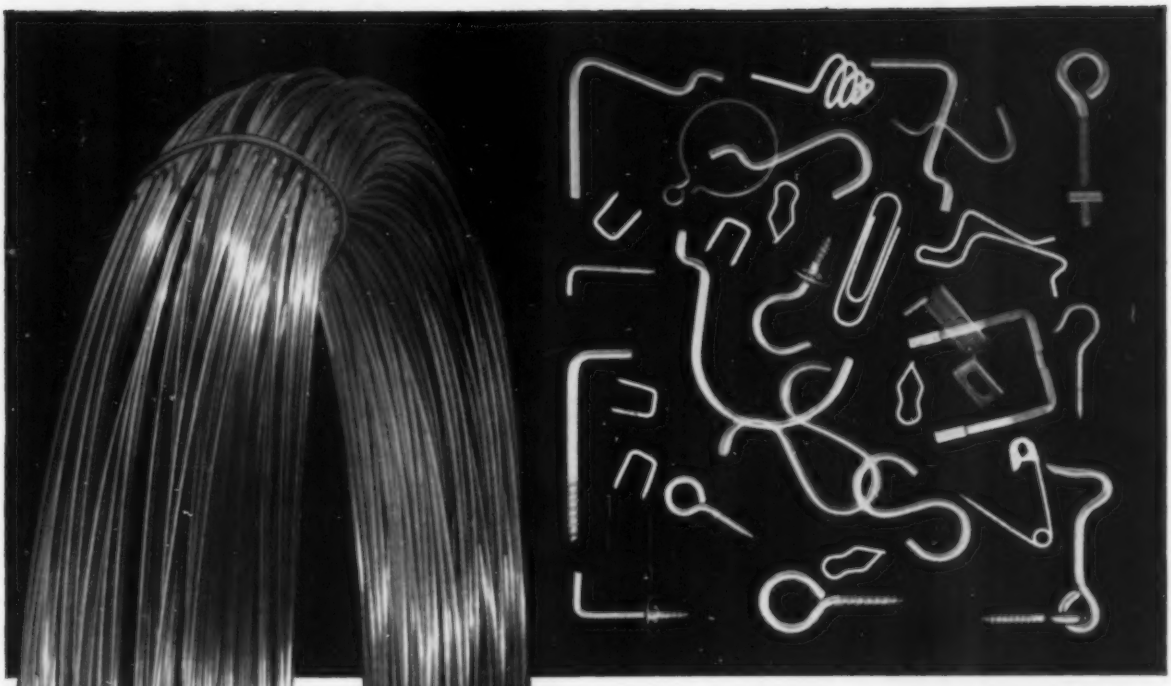
Circle 66, inside back cover

TYPE 430 STAINLESS STEEL—Brochure, 28 pp. Detailed information on this nickel-free straight chromium stainless grade. Describes physical properties and analysis, corrosion resistance, surface characteristics, fabrication, application, maintenance and bacteria removal, military specifications, and availability. Washington Steel Corp., Washington, Penn.

Circle 67, inside back cover

PILLOW BLOCKS—Bulletin A-668, 8 pp. Describes spherical roller bearing pillow blocks. With photos, engineering drawings, tabular data on dimensions,

(Continued on page 169)



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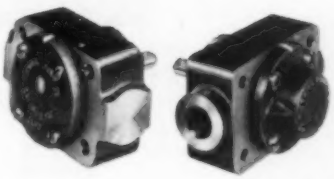
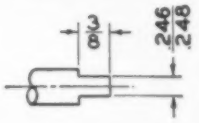
NOW! Have Reliable Lubrication at Minimum Cost

Models LF and RF
Capacities 55-170 g.p.h. at 1800 r.p.m.
Designed for flange mounting without shaft seal; with *choice* of internal or external porting. Model RF has automatic reversing feature which permits driving the pump in either direction... without changing direction of flow or port positions.

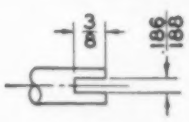


Models LFD and RFD
Capacities 60-180 g.p.h. at 1800 r.p.m.
Designed for non-directional service; for flange mounting with internal porting. Variations for external porting and/or shaft seal are shown below. Model RFD has the automatic reversing feature which permits driving the pump in either direction... without changing direction of flow or port positions.

ALTERNATE SHAFT DRIVE ENDS
For All Models



MODIFICATION "A"



MODIFICATION "B"

Tuthill "Cartridge-Type" Pumps Solve This Problem for Plant Maintenance...and Original Equipment Manufacturing

Durable—Reliable—and Available from Stock!

1. The demand for minimum cost lubrication pumps without sacrifice in performance, durability and reliability is *ideally* satisfied by the TUTHILL series of Models LF, RF, LFD and RFD *cartridge-type* pumps.

2. TUTHILL "cartridge" pumps get their reputation as cost-savers from their special design for original equipment use, their durable construction, their reliability...and the fact that they are *available from stock*. Note their compact size as shown in the photos above. Consider how all waste space has been eliminated for more adaptability. Think how they can be easily applied to your *own* requirements...in your plant...or in your equipment manufacturing plans.

3. These variables are available:

a. Pumps with...*or without*...automatic reversing performance

b. Pumps with...*or without*...a shaft seal

c. Pumps with internal...*or external*...porting

d. Pumps with *variations* of both internal and external porting

4. TUTHILL Catalog Section 108 contains line drawings showing each model in detail, shaft rotation and porting arrangements and other vital statistics to help you select the RIGHT model. Fill out the attached coupon—or write.

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963 E. 95th Street, Chicago 19, Illinois

Gentlemen:

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☐ Please send the complete catalog on the Tuthill line
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COMPANY_____

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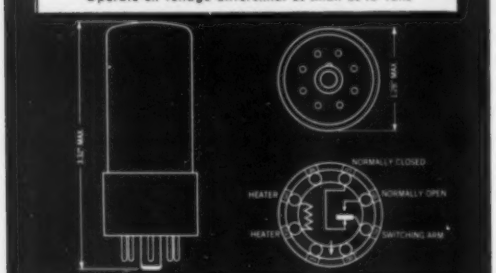
And if you're the man whose product needs this Tung-Sol Relay, then it's you I'm fishing for.

Tung-Sol makes an extensive line of relays in the general operating range typified by the No. 609. Simplicity of construction provides utmost reliability under extreme service conditions.

Snap-action principle of operating permits almost instantaneous response to current conditions. Cycling is extremely uniform. Compact and lightweight, Tung-Sol Relays are ideal for instrument, equipment and missile applications.

NOMINAL DESIGN CONSIDERATIONS

Contact capacity.....1 amp 30 volt resistive
Contact arrangement.....SPST (NC) or SPDT
Operating power.....As low as ½ watt
Time delays.....Up to 5 seconds
Operate on current differential as small as .05 amps
Operate on voltage differential as small as .3 volts



NOMINAL CHARACTERISTICS OF 609

Operating voltage.....6.4 volts
Operating time.....1. plus or minus .5 seconds
Release time.....1. plus or minus .5 seconds
Contact capacity.....1 amp at 30 volts
Contact arrangement.....SPDT

For additional data write:
Electroswitch Division, Tung-Sol Electric Inc., Newark 4, N. J.
Sales Offices: Atlanta, Ga.; Columbus, Ohio; Culver City, Calif.; Dallas, Tex.; Denver, Colo.; Detroit, Mich.; Irvington, N. J.; Melrose Park, Ill.; Newark, N. J.; Philadelphia, Pa.; Seattle, Wash. Canada: Montreal, P. Q.

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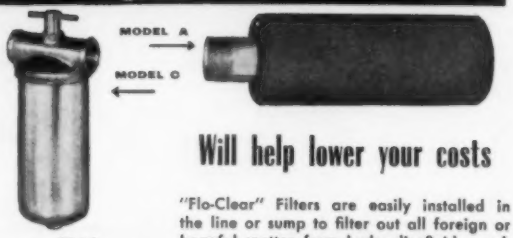
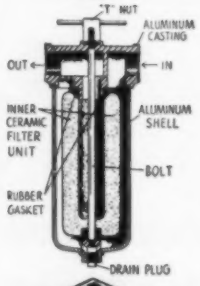
"Flo-Clear" FILTERS
for All Hydraulic & Fluid Uses



Will help lower your costs



"Flo-Clear" Filters are easily installed in the line or sump to filter out all foreign or harmful matter from hydraulic fluids, coolants, other liquid or water lines. Protects pumps from grit, abrasives, other harmful suspended matter. Easily cleaned, nothing to break or wear out, reusable indefinitely, more reasonable in cost than any other equipment of comparable quality and performance. Available in 4 models of 8 standard sizes and in fine, medium, and coarse pore sizes. Several other types of ceramic material available. Our engineers will be happy to work with you to develop filters for special applications. Write for Free Circular on "Hydraulic Filters for Original Equipment."

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shaft sizes, weights, and radial load ratings. Dodge Mfg. Corp., Mishawaka, Ind.
Circle 68, inside back cover

INDUSTRIAL HYDRAULIC EQUIPMENT—Catalog, 12 pp. Heavy-duty equipment for the 1000 to 3000-psi range, and higher, is described and illustrated. Features are explained. Included are pumps, valves, cylinders, presses and special hydraulic systems. Benjamin Lassman & Son, Route 8, Glenshaw, Penn.
Circle 69, inside back cover

ROLLED PATTERNS IN STEEL—Booklet, 16 pp. Gives information on sizes, patterns and numbers available, product uses, pictures of designs and products made from this material and methods of fabrication. Sharon Steel Corp., Sharon, Penn.
Circle 70, inside back cover

FLEXIBLE COUPLINGS—Catalog 7; 8 pp. Describes and illustrates taper-bushed flexible couplings. Charts show horsepower ratings, dimensions, maximum rpm and other engineering data necessary for selection. Diamond Chain Co., Inc., Dept. 443, 402 Kentucky Ave., Indianapolis 7.
Circle 71, inside back cover

IRON-NICKEL STEEL—Data sheet, 20 pp. Information on electrical steel 4750, including physical, mechanical and magnetic properties. With 16 graphs. Allegheny Ludlum Steel Corp., Oliver Bldg., Pittsburgh 22.
Circle 72, inside back cover

TIME INTERVAL MEASUREMENTS—Booklet 112, 9 pp. Covers descriptions of time interval meters, measurement of pulse width and elapsed time, low-frequency period measurements, timing relay operations; also covers use of time interval meters to test camera-shutter speed and measure velocity. Beckman-Berkeley Div., 2200 Wright Ave., Richmond, Calif.
Circle 73, inside back cover

BALLS AND BEARING PRODUCTS—Catalog, 16 pp. Guide to selection of precision balls, including quick selector chart. Comprehensive data on balls of aluminum, brass and bronze, carbon steel, chrome alloy steel, glass, K-monel, plastic, stainless steel, and special materials. Hartford Steel Ball Co., 12 Jefferson Ave., West Hartford, Conn.
Circle 74, inside back cover

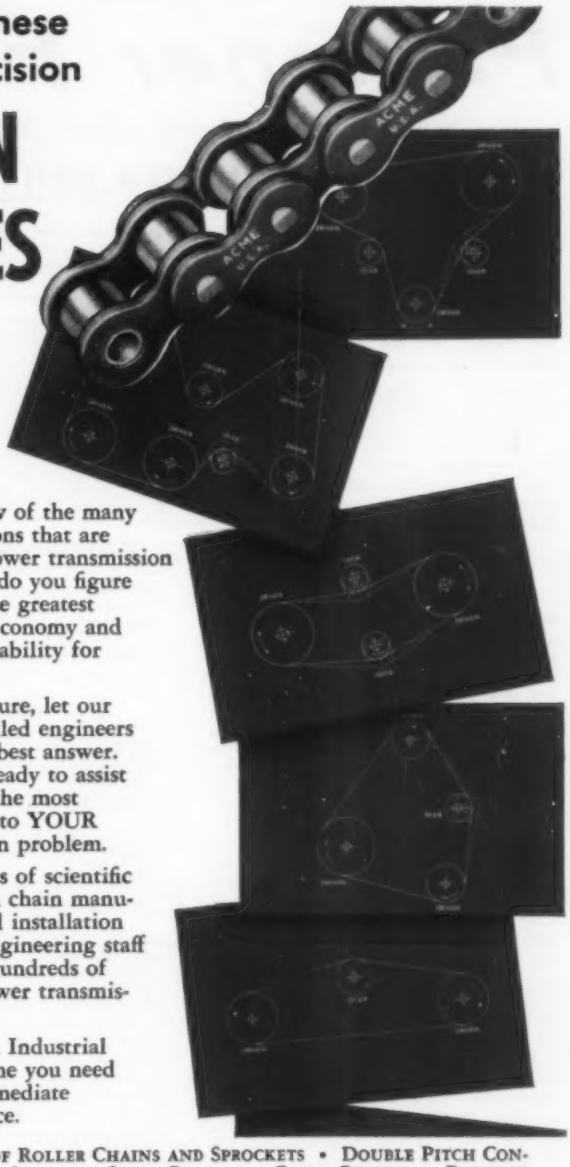
TITANIUM CARBIDE ALLOYS—Bulletin B-444, 12 pp. Parts of simple and complex shapes are described; physical properties of 13 different compositions and corrosion resistance are tabulated and

(Continued on page 172)

Which of these ACME Precision

CHAIN DRIVES

will help you drive it better?



Here are just a few of the many chain drive positions that are unsurpassed for power transmission efficiency. Which do you figure would give you the greatest efficiency, lowest economy and longer-life dependability for your application?

To be absolutely sure, let our staff of highly skilled engineers help you find the best answer. They are always ready to assist you in obtaining the most desirable solution to YOUR power transmission problem.

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by Henry Peterson, Chief Engineer — Judson L. Thomson Mfg. Co.

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Millions of Thomson Deep-Drilled Rivets are used each year by leading manufacturers of leather goods, luggage, shoe skates, baseball shoes, camera cases, hand bags, golf bags, and other sporting goods. These self-piercing rivets are used to replace or reinforce stitching.

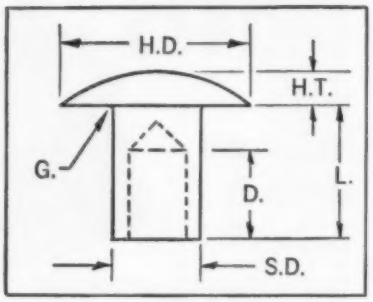
How you benefit:

With Thomson Deep-Drilled Rivets, you can eliminate the cost of pre-punching or pre-drilling holes in materials. Drilled to a depth up to ½" they punch their own holes through the material and compress it within their hollow shanks. Clinched by high-speed automatic rivet-setting machines, which can be operated by unskilled help, they keep assembly time and costs at a minimum.

What dimensions:

Hole Depth (D) of standard deep-drilled rivets always exceeds shank diameter, but never exceeds ½". Exact depth is determined by the compressibility of materials to be fastened and by the clinch requirements of the application. A rule of thumb is to add shank diameter to the thickness of the compressed assembly. The safe rule is to have tests run on actual samples.

Head Diameter (H.D.) ranges between 1.75 and 2.75 times shank diameter for rivets produced by single-blow heading machines. Head diameters up to 3½ times shank diameter are possible . . . at higher cost.



Head Thickness (H.T.) ranges from 0.3 to 0.6 times shank diameter, depending on head shape: oval, flat countersunk, ideal, beveled flat countersunk or cone.

Shank Diameter (S.D.) of standard sizes ranges from .040" to .320".

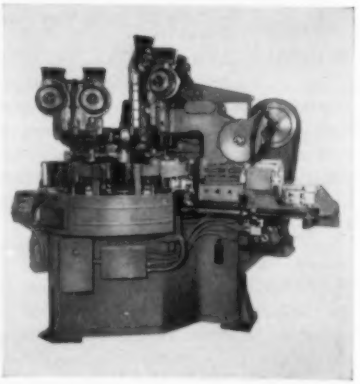
How Clinched:

You have a choice of two clinches with Thomson Deep-Drilled Rivets, depending on the required strength: roll clinch or scored clinch. Roll clinch, produced by correctly-shaped anvils (either solid or spring pilot type), is stronger. Scored clinch is specified when clinch must be turned into the surface of the work.

Thomson Deep-Drilled Rivets are also clinched inside caps which match rivet heads to improve the appearance of the assembly and increase the strength. Washers (burrs) are also used to prevent the clinch from tearing loose by giving a stronger bearing against soft surfaces.

High Speed Setting Machines:

The inherent economy of rivets as fasteners is multiplied by high-speed assembly with automatic rivet-setting machines. Thomson has developed more than 250 styles of machines which can do thousands of fastening jobs . . . with or without adaptations. Multiple rivet-setting heads, special work handling and loading fixtures are optional features that accelerate riveting operations. Thomson selects and custom-tools the proper machine to speed assembly and reduce costs. Available on a sale or lease basis.



Automatic Rivet-Setting Machine

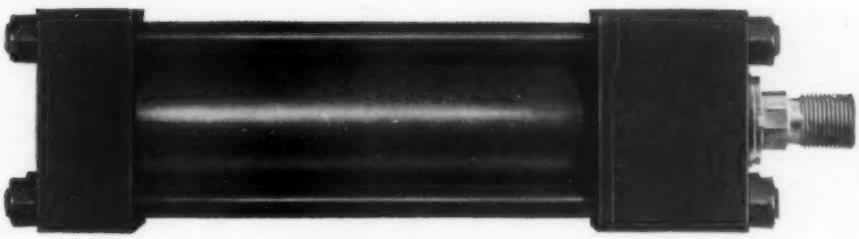
Design and engineering service:

Thomson analyzes your company's fastening problems and makes specific rivet and machine recommendations . . . at your request. When called in early, we can often meet your requirements with standard rivets and machines that eliminate the need for costly special fasteners and tooling. For work in progress, submit sketches, prints or samples for suggestions and quotations.

Free "Fasteners Fact File"

Our new manual on all phases of riveting belongs in the hands of everyone who specifies or buys fasteners. It covers rivet types, applications, materials and other factors that determine the selection of the right design, rivet and machine for cutting fastening costs. Request your copy today. Write Judson L. Thomson Mfg. Co., Department C, Waltham 54, Mass.

JUDSON L. THOMSON MFG. CO., WALTHAM 54, MASS.



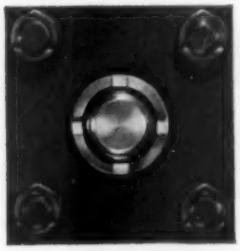
designed for leadership!

The superiority of Hannifin cylinders begins on the drawing board, where Hannifin designers have originated feature after feature not found in other air and hydraulic cylinders. But it doesn't end there...

Hannifin offers more kinds of cylinders, more sizes, more mounting styles. Each manufactured with such exacting control of dimensions and finishes that it not only looks like a better cylinder—its performance proves it!

As more and more discriminating specifiers and buyers are finding, the extra quality you get from Hannifin costs you no more, can usually be delivered sooner.

Why not specify Hannifin by name when you buy?



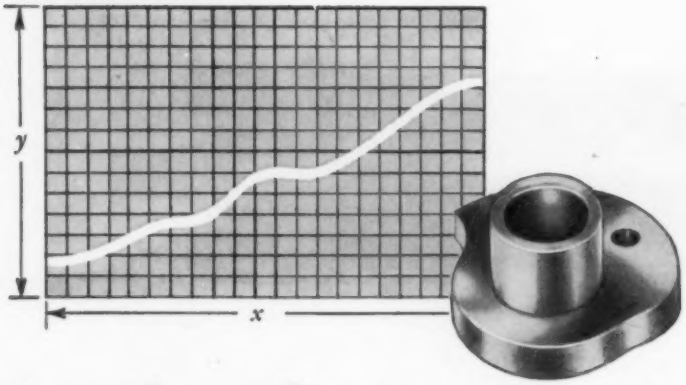
AIR AND HYDRAULIC

HANNIFIN

POWER CYLINDERS

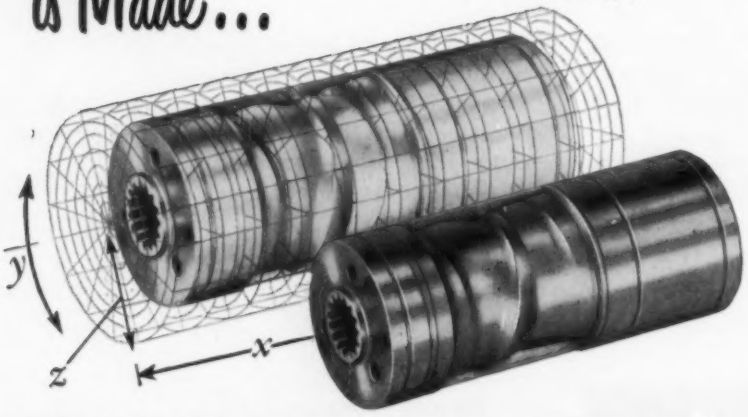
Write for your copy of this new Hannifin Cylinder File—complete, easy-to-use, easy-to-order-from information on five lines of Hannifin cylinders. Hannifin Corporation, 525 South Wolf Road, Des Plaines, Illinois.

Here's How a 2 Dimensional Cam is Made...



Here's How a 3 Dimensional Cam is Made...

$z = f(x,y)$



HERE'S HOW YOU CAN GET THE GRAPHIC STORY OF CAMS THAT "COULDN'T BE BUILT"—*BUT WERE DELIVERED BY PARKER!*

Send today for the new, fact-filled Parker folder—discover how Parker can engineer and build three dimensional cams with an infinite number of precisely machined stations to serve as the "brains" for a wide range of automatic operations.

THE PARKER-HARTFORD CORPORATION
CAM DIVISION
FRANKLIN AVENUE • HARTFORD, CONNECTICUT

by Parker

charted to show the effects of temperature and exposure time. Kennametal, Inc., Latrobe, Penn.

Circle 75, inside back cover

SHELL-MOLDED CASTINGS—Booklet DB-52-520, 8 pp. Discusses process quality control, design considerations, materials and typical castings. Westinghouse Electric Corp., P O. Box 2099, Pittsburgh 30.

Circle 76, inside back cover

SWIVEL JOINTS—Manual AM-11, 22 pp. Data on dimensions, installation, and assembly methods. Weatherhead Co., Aviation Div., 300 E. 131 St., Cleveland.

Circle 77, inside back cover

SYNTHETIC LUBRICANTS—Brochure, 24 pp. Manual on development, properties, testing and application of lubricants. Compares these lubricants with petroleum products. Industrial Service Dept., Lehigh Chemical Co., Chestertown, Md.

Circle 78, inside back cover

ALUMINUM BIBLIOGRAPHY—Booklet, 8 pp. A listing of literature and motion pictures of possible interest to designers. Aluminum Co. of America, Room 799, Alcoa Bldg., Mellon Square, Pittsburgh 19.

Circle 79, inside back cover

POLYESTER RESINS—Booklet PL-316, 36 pp. Discusses properties of Paraplex P-series, including Paraplex P-444. Supplemented by data tables and performance graphs. Rohm & Haas Co., Washington Sq., Philadelphia 5.

Circle 80, inside back cover

MOTORS AND GENERATORS—Catalog folder, 16 bulletins. Each gives application and specification data with product description. Illustrated with photos. Bulletins cover high-frequency motors, motor generators, engine generators, special electrical equipment, and gear motors. Motoresearch Co., Racine, Wis.

Circle 81, inside back cover

Letterhead Requests Only

Manufacturers who published following literature ask that requests for copies be made on company letterheads.

POTENTIOMETER SELECTOR—Circular chart. The plasti-coated selector has an inner rotating wheel that visualizes mechanical and electrical specifications of the complete line. Window cutouts illustrate 19 models and give complete factual data. Reverse side gives specifications. Electronic Sales Div., DeJur-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y.

ENTER THIS CONTEST ...90 CASH PRIZES!

CONTEST RULES

1. Tell in 25 words or less "Why I prefer Albanene tracing paper."
2. Send all entries to K&E Albanene Contest, Box 160, New York 46, N. Y. Enter as often as you wish. There is nothing to buy.
3. Entries must be postmarked not later than midnight, Nov. 30, 1957.
4. Entries become the property of Keuffel & Esser Co. None can be returned.
5. The decision of the judges is final.
6. Winners will be notified by mail. A complete list of winners will be sent upon request, providing request is accompanied by stamped, self-addressed envelope.
7. Contest is open to all residents of continental United States, except employes, and their immediate families, of Keuffel & Esser Co. and its subsidiaries and dealers; its advertising agency; and judges of this contest.
8. Also not applicable to residents of those states where there are prohibitory laws.

Why I prefer **ALBANENE**® Tracing Paper...

First prize **$1500**
Second prize **$1000**
Third prize . . . . . **$ 500**

plus 87 prizes of $25 each!

In 25 words or less, tell us why you prefer K&E Albanene® tracing paper. Your reasons may win one of these 90 prizes (it's K&E's 90th anniversary).

Here's a hint: Albanene is made from 100% rag stock for superlative tear strength. It is permanently transparentized with an inert resin. Draftsmen like it because of its easy drawing qualities . . . reproduction men for its high transparency and permanence. Everybody likes it because "what you pay for stays in the paper." That's why Albanene is the best seller among *all* tracing papers.

Get contest aids from your K&E dealer: Information booklets, extra contest entry blanks, samples of Albanene, too, if you need them. You can enter as often as you please.

Or use a plain sheet of paper if someone's already snipped the blank below. Give your name, address, and firm name, twenty-five words or less telling why you prefer Albanene tracing paper, and mail to K&E Albanene Contest, Box 160, New York 46, N. Y. before midnight, November 30, 1957.

KEUFFEL & ESSER CO.
New York, Hoboken, N. J., Detroit, Montreal, Chicago, St. Louis, Dallas, San Francisco, Los Angeles, Seattle.
Dealers in principal cities

K & E Albanene Contest, Box 160, New York 46, N. Y.

Here's why I prefer Albanene Tracing Papers_____

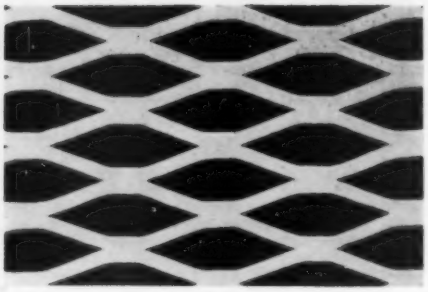
_____

_____

*Name*_____ *City*_____ *Zone*_____ *State*_____

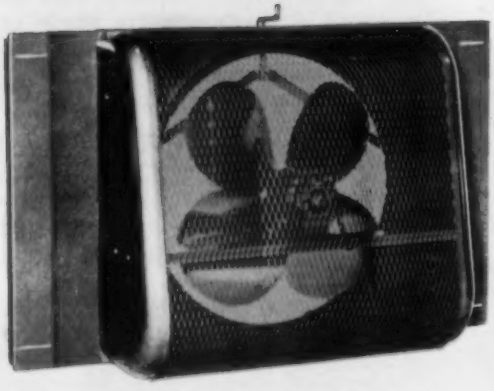
*Street*_____ *Firm Name*_____

They designed for strength and style with expanded metal grilles



Bi-directional speaker baffle by Lowell Manufacturing Co., St. Louis, Mo., incorporates a grille of Penmetal 3/16" aluminum Minimesh.

Palmaire electric heaters feature Penmetal expanded metal grille, with baked enamel finish.



Window ventilating fan made by Atlas Tool & Manufacturing Co., St. Louis, Mo. Enclosure is Penmetal expanded metal.

Smart, trim lines . . . strength with lightness . . . free passage of air . . . these are the qualities designers gain with Penmetal expanded metal. And, combined with surprisingly low cost, they are the reasons more and more expanded metal is being specified for grilles, as well as for countless other applications.

Penmetal expanded metal comes in standard or flattened form in a wide variety of mesh sizes to meet any specific need. Can be galvanized, tinned, polished, plated, enamelled. Easily cut, shaped or welded to suit design requirements.

So, if your product incorporates a grille, don't overlook Penmetal expanded metal. It's a simple, sure way to greater sales acceptance.

Send for catalog 515-EM which shows mesh sizes, weights and dimensions. No cost or obligation.

PENN METAL COMPANY, INC.

General Sales Office:
40 Central Street, Boston 9, Mass.

Plant: Parkersburg, W. Va.
District Sales Offices: Boston, New York, Philadelphia, Pittsburgh, Chicago, Detroit, St. Louis, Dallas, Little Rock, Seattle, San Francisco, Los Angeles, Parkersburg

METAL MARK Penmetal 1869 OF QUALITY

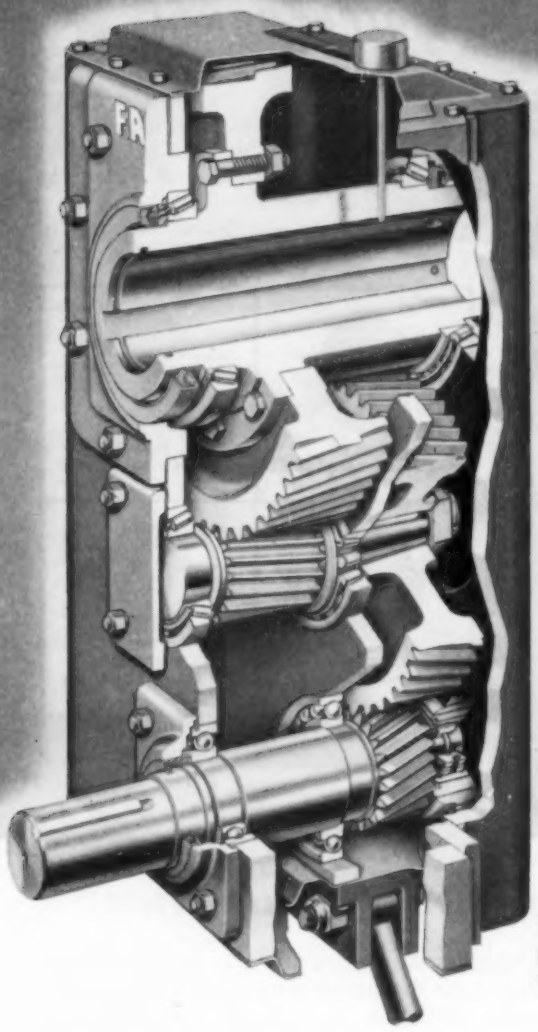
a name to remember

PM-159

New...LARGER...ALL-STEEL!

-the FALK 315J Shaft Mounted Drive

- **for higher horsepower**
- **for lower output speeds**



THE NEW 315J...
FROM 2 HP AT 5 RPM
TO 50 HP AT 359 RPM

Check These Features

New — 3-wall, one-piece housing provides double the ability of cast iron to withstand external impact or shock loads.

New — ratio range—5:1, 14:1 or 25:1. Higher ratio range makes possible lower output speeds...smaller sheaves...standard, rather than slow-speed, motor.

New — ease of maintenance. All revolving elements can be easily replaced in the field, on the jobsite! Inspection covers permit quick inspection of gears and bearings. Dipstick provides quick check on lubricant.

New — longer center distance between shafts allows use of larger sheave on input shaft. Unit may be mounted with input shaft next to driven machine, and with motor mounted directly under driven shaft.

PROMPT DELIVERY

Standard units are available for off-the-shelf shipment from factory, warehouse or distributor stock.

LET US HELP YOU

Your Falk Representative or Authorized Falk Distributor will gladly review your applications and offer suggested selections—without obligation.

Write for Bulletin 7100

The new Falk 315J also gives you these famous Falk advantages—

- Falk extra-depth, extra-capacity gear teeth—plus the extra efficiency (98½% per gear mesh) of helical gears for maximum power utilization.
- Through-hollow shaft design for easy installation, with internal groove to permit use of bearing puller when dismounting unit. Hollow shaft also permits use of unit on through-shaft applications.
- Tie rod fastened to steel housing by steel bracket with bolt in double shear. Shock load on tie rod will not damage housing.

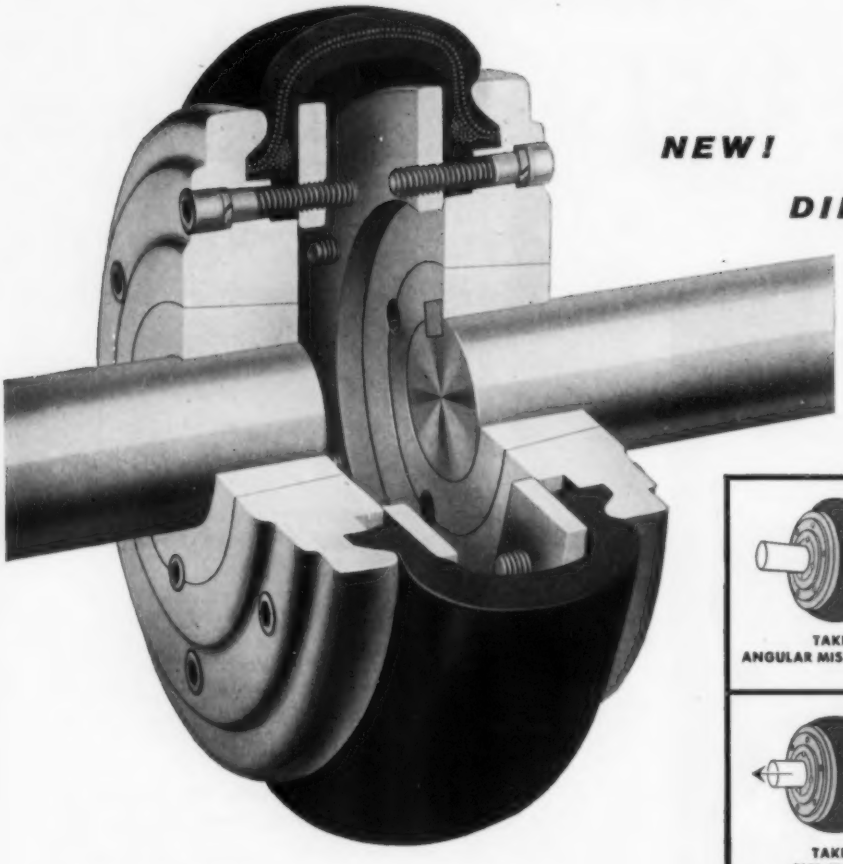
THE FALK CORPORATION, MILWAUKEE 1, WISCONSIN

Representatives and Distributors in Most Principal Cities

Manufacturers of Quality Gear Drives and Flexible Shaft Couplings

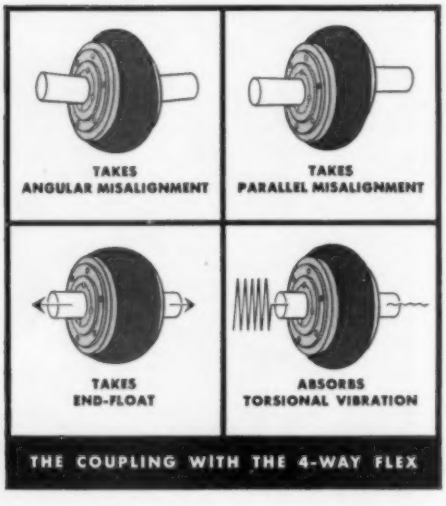
FALK

...a good name in industry



NEW!

DIFFERENT!



Announcing

Para-flex

FLEXIBLE CUSHION COUPLING

THIS coupling "swallows up" shaft misplacements. It automatically compensates for end-float, parallel misalignment, angular misalignment *or any combination of all three.* Moreover, it cushions the stresses of shock loads. And it absorbs torsional vibration—reducing noise and protecting machinery from vibration's destructive forces.

Here is a new type of performance—made possible by the development of a tire-like flexing element. Synthetic tension members, bonded together in rubber, give this element the stamina and dependability of modern, high-speed, high-load, shock-absorbing truck tires—and the ability to respond magically to all manner of changing shaft conditions.

Para-flex takes minimum space on the shaft. Mounting is simplified through the use of standard Taper-Lock bushings—no reboring, no machining. Safety is promoted by flush design; there are no protruding parts. No lubrication is required, no periodic inspection. And since the flexible member is molded with a transverse split, it can be replaced *without moving either the driver or driven machine.*

Para-flex Couplings are stocked by Dodge Distributors in popular transmission sizes. They are available from factory stock in capacities up to 600 hp at 900 rpm. Call your distributor for early delivery to *make your own test.* You'll witness something revolutionary!

DODGE MANUFACTURING CORPORATION, 1200 Union, Mishawaka, Ind.

DODGE

of Mishawaka, Ind.

CALL THE TRANSMISSIONEER, your local Dodge Distributor. Factory trained by Dodge, he can give you valuable assistance on new methods. Look for his name under "Power Transmission Machinery" in the yellow pages of your classified telephone directory—or write us.

tangents...

How to Train Your Successor

Prince Rainier of Monaco isn't the only ruler who must provide a male successor—he's just the most-publicized one. Every industrial executive has the same problem, but can't choose such an attractive way to solve it. You have the same responsibility, too, albeit for different reasons.

Presumably, when Prince Rainier's successor is crowned, the Prince himself will not be concerned. He'll be dead. His is a dead-end job; he starts at the top. But your job isn't dead-end—unless you make it so. There's always some place for you to go—*if* your successor is ready and waiting. His readiness is a testimonial to both his own ability and to your training.

Once, not too many years ago, the popular technique was to attain job security by holding down subordinates and by firing the occasional challenger. It was just a refined form of the technique of herd bulls. That's still standard practice in some organizations. But not in most.

However, in too many cases, there is as yet no real appreciation of the importance of training the Number Two's. They are expected to stand by, taking the less-palatable assignments, apprenticing for the larger responsibility but not having any of it until they get it all. In many respects, the training method is haphazard—much like that of most parents for children.

Such training is likely to produce the same complications as inadequate child training. The parent who feels confident that his child's character will be shaped entirely by schools, Scouts, and associates (so he personally can evade both effort and responsibility), is matched by the industrial executive who assumes that societies, associations, associates, and distilled business-school courses are going to do his training job for him.

The man who hasn't an engineering turn of mind may on occasion get an engineering degree, but he'll never be an engineer. Likewise, the man without a management turn of mind can never be converted into a manager by a quickie course. All the outside training can do is to polish off some rough spots and provide general answers to some questions. If the stuff isn't there in the first place, and if it hasn't been properly developed and directed in the second, no outside teacher can do much. The Age of Miracles—at least in this field—is over.

Your abilities and your potential for promotion can usually be judged by taking a good look at your assistant. It is, therefore, of prime importance to you to see that he knows what he's about. Here are ten pointers for making him effective:

Ten Comandments for Training Your Successor

1. Don't solve all his problems for him. When he brings a problem to you, expect him also to have an answer—his best. Check to see that it isn't always also his first. Help him to analyze the problem and work out a logical solution so he understands that there's more to problem solving than inspiration. If his solution is workable, say so—and help him with it.

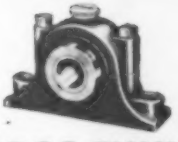
2. Help him to save his time—and yours. He must learn to cut away the unimportant so he can attack the real job at its core—and present it to you the same way.

3. Give him responsibility as fast as he can take it. Turn over part of your job to him—and let him run it. Stay out unless there's a real emergency or unless he asks for help. Respect the authority you're giving him—or others won't either.

4. When his idea is almost as good as yours, let him try it. The fastest way to kill initiative is to overrule arbitrarily; the fastest way to kill suggestions is to belittle, ignore, or refuse them. And, most important, if his idea works, be sure he gets credit.

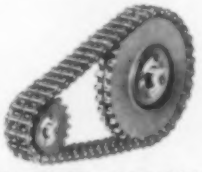
5. Back him up. If he issues an order, consider it as yours. If it's wrong, explain it to him—and let him withdraw it. If you show public doubt or disagreement with him, you cancel his effectiveness in the eyes of his subordinates. They'll support you rather than him in most cases—not because you're right, but because they know on which side their bread is buttered.

(Continued on page 179)



DODGE-TIMKEN
America's Quality Pillow Blocks!

TAPER-LOCK
SHEAVES
Easy on—easy off! Mount flush!



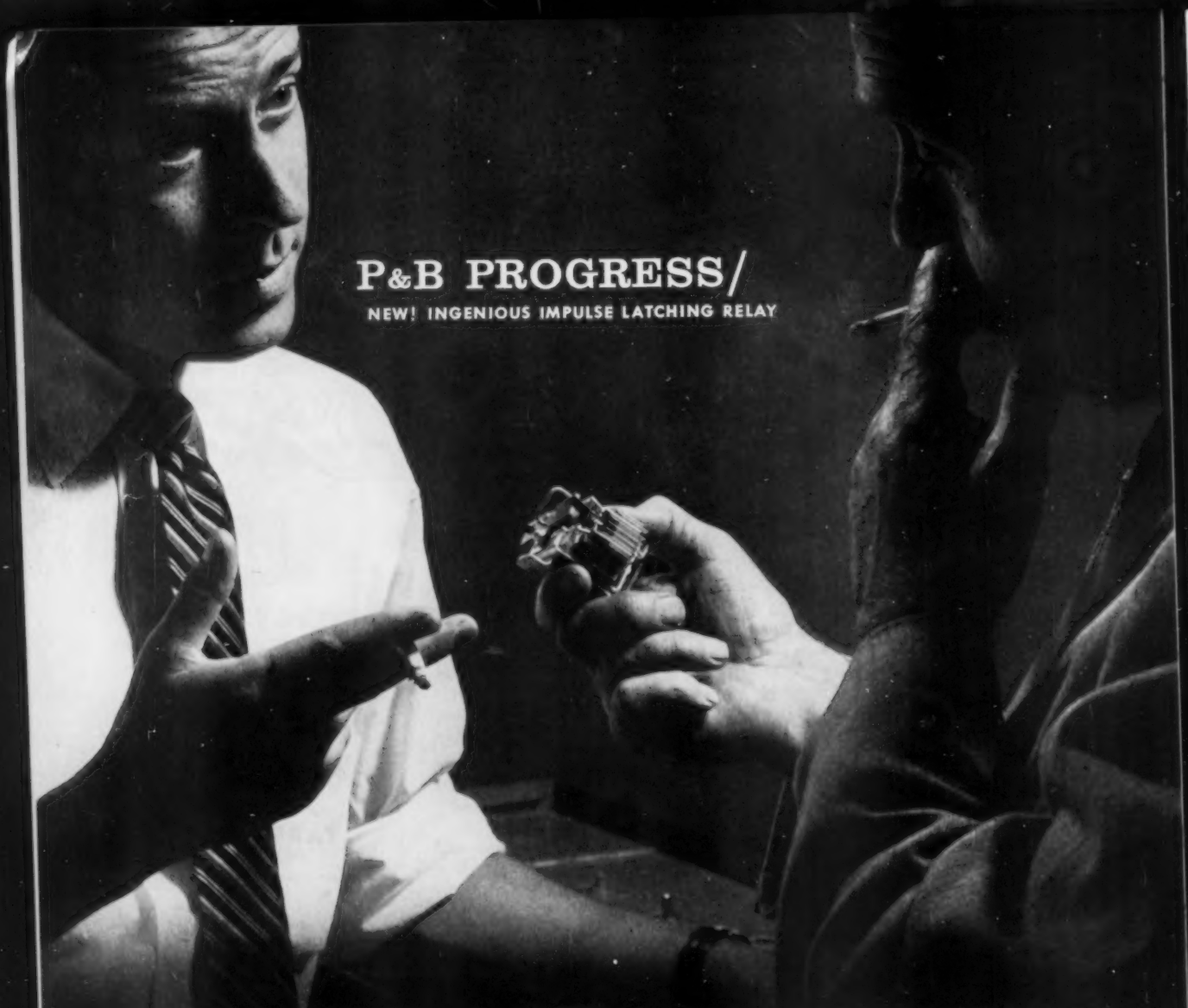
TAPER-LOCK
SPROCKETS
No reboring—no waiting!

Write for Bulletins!

- Roller Bearings. Load ratings, dimensions, etc. Bulletin A-638.
- Taper-Lock Sheaves. Drive tables and technical data. Bulletin A-661.
- Taper-Lock Sprocket and Dodge Roller Chain data. Bulletin A-644.

DODGE MANUFACTURING CORPORATION
1200 Union Street • Mishawaka, Indiana

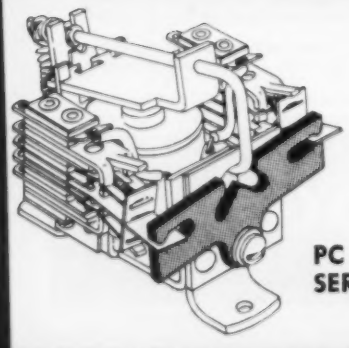
DODGE
of Mishawaka, Ind.



P&B PROGRESS/

NEW! INGENIOUS IMPULSE LATCHING RELAY

NOW! TWO-COIL PERFORMANCE AT SINGLE COIL COST!



PC SERIES

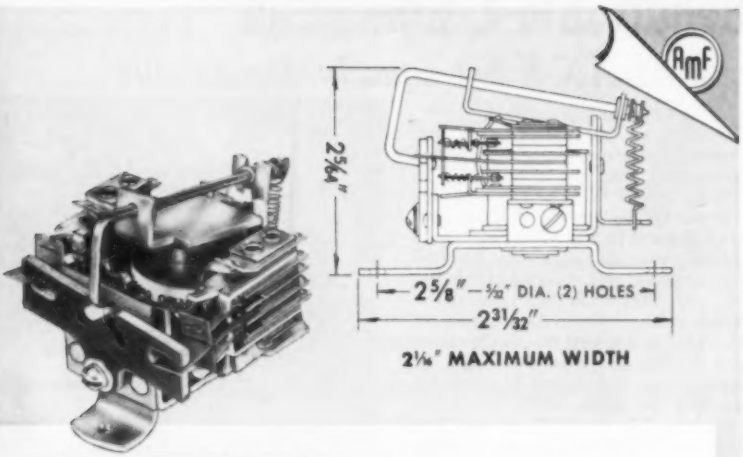
This new series, the PC, is an ingenious impulse latching relay which employs a single coil and armature to activate an insulated rocker arm. Switching is positive, fast (30 milliseconds).

Its low cost, dependability and versatility make it ideal for a wide range of uses. For example, two leading TV set manufacturers use the PC in their remote control circuits as an "off-on" switch. It is also used by a maker of automatic garage doors. Conveying systems, automatic processing equipment, flow controls—the PC is right for these applications and many more.

Contact arrangements are available up to 4 Form C (4PDT), and the snap-action contacts are rated 5 amps. at 115 V. AC resistive. The relay may be ordered open, as shown, or in a metal dust cover.

Write or wire today for complete information.

POTTER & BRUMFIELD, INC., PRINCETON, INDIANA / SUBSIDIARY OF AMERICAN MACHINE & FOUNDRY COMPANY



PC SERIES ENGINEERING DATA

GENERAL: Description: Single coil, impulse latching relay.
Insulating Material: Laminated Phenolic.
Insulation Resistance: 1500 megs. min.
Breakdown Voltage: 500 V. RMS.
Ambient Temperature: —55° C. to +85° C.
Weight: 5 ozs. (open)
Pull-In: DC, 75% / AC, 78% } for nominal voltage.
Operate: 30 MS.
Terminals: Pierced Solder Lugs
Coil: Two #20 AWG Wires
Contacts: One #20 AWG Wire
Enclosures: "A" Can.

CONTACTS: Arrangements: 4 Form C. max. (4PDT)
Material: ⅛" dia. Silver Cadmium oxide gold flashed.
Load: 5 amp. @ 115 V. AC resistive.
Pressure: 20 grms. min.

COIL: Resistance: .016 to 34,500 max.
Power: DC, 9 watts. / AC, 18.4 Volt Amps. } at nominal voltage.
Duty: Intermittant.
Insulation: Cellulose acetate wrap; varnish impregnated (open).

MOUNTINGS: Two 1/32" dia. holes on 2⅝" center.

P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC, ELECTRICAL AND REFRIGERATION DISTRIBUTORS

Potter & Brumfield, inc.

PRINCETON, INDIANA
SUBSIDIARY OF AMERICAN MACHINE & FOUNDRY COMPANY
Manufacturing Divisions also in Franklin, Ky. and Laconia, N.H.

Mail the coupon below for further engineering data on P&B's new PC Series relays *plus* new compact catalog of standard type relays. If you need answers to a specific application problem, write in detail.

Potter & Brumfield, Inc., Princeton, Indiana
Attn: T. B. White, Brig. Gen. USMC (Ret.)
Special Projects Engineer

Please send me complete data on the new PC Series relays, plus the new compact catalog of P&B standard relays.

Name_____

Company_____

Address_____

City_____ Zone____ State_____

See our catalog in Sweet's Product Design File

6. Don't make him a sneak by over-criticizing his errors. Everybody makes mistakes; show you know it by being fair, even leaning over backward when he admits them promptly. Your job is to help, not punish. If he tries to pass the buck to his subordinates, then hit hard, because he is responsible for what they do, and had better learn it.

7. Teach him to "take it." He must learn to accept constructive criticism, must see that it helps him. Occasionally, he must even accept unfair criticism for the good of the job. There's a time to stand up and fight, but it isn't at the first critical word. Your approval of his grit, your understanding of his self-denial, is vital at times like these.

8. Keep him informed. Be sure he knows what you're doing, and why. Don't work behind his back, and don't think there are some things he's too young or too inexperienced to know. If he spills your plans, he's no candidate for your job, and you'd better learn it sooner rather than later.

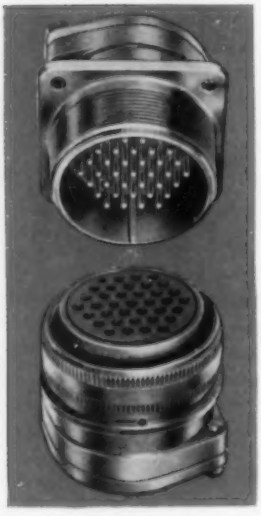
9. Give him of your time, and teach him as you go. He can't learn everything by osmosis; he must be taught like anyone else. Let him sit in on your sessions with others, so he can see how you handle situations. And be sure he reports to you regularly.

10. Be particularly certain he has the chance to see how tough personnel and budgetary problems are handled. These are the most frequent areas of inadequacy in new executives—because they've had no chance to learn. And ask your assistant's advice on such cases occasionally; remember that his point of view may be closer to the problem than yours. —EJT

"What d'ya mean . . . 'Subconsciously' you're hard at work?"

New Bendix SM-E Connector

(smaller, lighter than AN-E but equally dependable)



Here is the newest in the ever growing family of Bendix* environment resistant connectors. The new SM-E Series (Short "E") will provide the same performance as the standard AN-E connectors, but is shorter, lighter and more easily serviced. Not only does this connector conform to the vibration resistant requirements of the "E" connector in the MIL-C-5015C government specification, but it also provides effective moisture barriers both at the solder well ends and mating surfaces using the full range of wire sizes. Of particular interest to production and maintenance people is the back nut design, which provides a jacking action on the grommet during disassembly, thereby lifting it free of the solder wells. This feature when combined with the new Bendix "slippery rubber" grommets makes easy work of wire threading and grommet travel over the wire bundles.

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DESIGN ABSTRACTS

Mechanical Impedance

Maxwell's analogy for mechanical and electrical systems is based on the fact that equations of motion for both systems are isomorphic. This allows electrical models to be made that will represent mechanical systems. Such "simulators," as these models are termed, enable complicated mechanical systems to be analyzed in the laboratory.

The impedance of a dash pot, for example, can be represented by resistance; mechanical filters or shock absorbers can be regarded, with the help of their equivalent circuits, as four-pole boxes. Scope of paper includes circuit theory, transducer, mobility analogy, non-reciprocal systems, and measurement of mechanical impedance.

Abstracted from "Analysis of Mechanical Impedance" by Richard K. Cook, National Bureau of Standards. Presented at SAE National Aeronautic Meeting, Los Angeles, Sept. 30-Oct. 5, 1957.

Selection of Shock and Vibration Isolators

This paper is a progress report of the SAE Subcommittee on Isolation Systems and presents some of the current thinking on the various subjects that have been considered. No single topic has been exhaustively studied, but isolator data, design procedure, and measurement of isolation characteristics are discussed.

Abstracted from "Selection of Shock and Vibrator Isolators" by Sheldon Rubin, Lockheed Aircraft Corp. Presented at SAE National Aeronautic Meeting, Los Angeles, Sept. 30-Oct. 5, 1957.

Physical Properties of Titanium and Its Alloys

There is always considerable doubt in an engineer's mind when confronted by tabulated properties of a material, both as to reliability and conditions of test compared to similar materials. The Titanium Metallurgical Laboratory at Battelle Memorial Institute has solved this problem on titanium by its activities as a clearing house and coordinator on titanium research activities. In report No. 73, TML has up-dated a previous report published last year covering the physical properties of pure titanium and its many alloys. Areas covered are: atomic structure, mass properties, and characteristics of the metals needed in thermal, electrical, magnetic, optical and electronic applications.

Attempts were made to compare, for all these categories, data of various investigators and to suggest best values when sufficient background information was available to form an opinion. Unreferenced data appearing in manufacturer's literature are tabulated without comment.

Abstracted from "The Physical Properties of Titanium and Titanium Alloys," by W. J. Lepkowski and J. W. Holladay, Titanium Metallurgical Laboratory Report No. 73, Battelle Memorial Institute, Columbus, Ohio.

Fatigue in Titanium and Its Alloys

Over the past year and a half, sufficient requests concerning the fatigue properties of titanium and its alloys have been directed to Battelle's Titanium Metallurgical Laboratory to warrant an information survey. The result is TML Report No. 77 which summarizes current status and shows that considerable data does, indeed, exist on fatigue behavior of these alloys. Factors of particular interest discussed in detail in the report are: (1) Unnotched fatigue strength, (2) Effect of notches, (3) Effect of surface preparation, (4) Metallurgical influences, and (5) Effect of Temperature. In addition to pure titanium, eight commercial alloys are also covered in this report.

The report suggests four areas for further study: (1) More on notch effects, (2) More on the effects of surface finishes like shot peening and grinding, (3) Influence of intersititial compounds on time and stress-dependent fatigue behavior, and (4) Effect of temperature on creep-rupture behavior.

Abstracted from "An Evaluation of Fatigue Properties of Titanium and Titanium Alloy," by J. G. Weinberg and I. E. Hanna, Titanium Metallurgical Laboratory Report No. 77, Battelle Memorial Institute, Columbus, Ohio.

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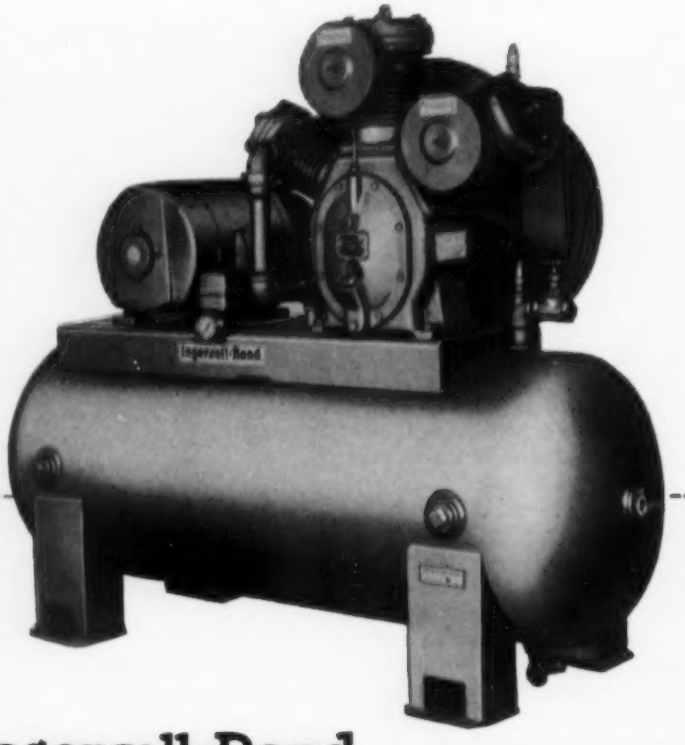

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NEW BOOKS

Semiconductor Abstracts

Abstracts of Literature on Semiconducting and Luminescent Materials and Their Applications, Volume III —1955 Issue, Compiled by Battelle Memorial Institute, sponsored by the Electrochemical Society, Inc., E. Paskell, Editor, 8¾ x 11¼ *in., 322 pp. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y.* $10.

This year's compilation of abstracts has been prepared jointly by members of the Solid State Devices Div. and the Physical Chemistry Div. of Battelle Memorial Institute. This compilation has grown rapidly and has been expanded to include papers presented at several technical society meetings and more thorough coverage of fringe areas.

Important results are included in most of the abstracts, reducing the need for original articles. Numerical results are included when possible. This is particularly valuable in the case of information presented at the technical society meetings covered.

As with previous issues, the principal source of information has been the abstract journals. However, many original articles have been reviewed.

Materials are the key in organization of the Abstracts. With the standardized organization of the individual chapters, it is generally possible to locate information rapidly from the table of contents. An extensive, cross-referenced subject index has also been provided together with an author index.

RCA Transistors and Semiconductor Diodes

Published by the RCA Semiconductor Division, 8½ x 11 *in., 24 pp. Obtainable from RCA Commercial Engineering, 415 S. Fifth St., Harrison, N. J.,* $0.25.

This booklet contains a general explanation of transistor theory and operation, with a section devoted to the RCA-developed "drift" type tran-

(Continued on page 184)

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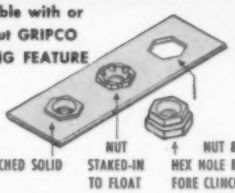

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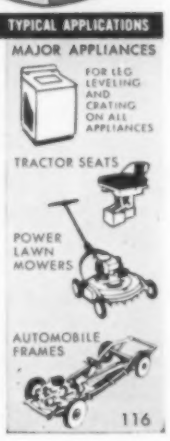

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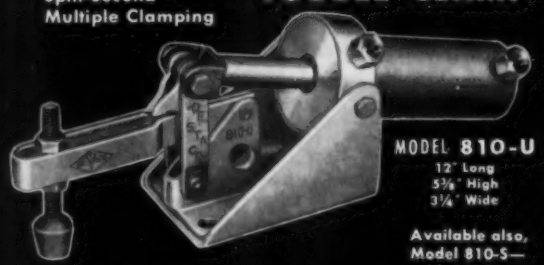

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sistor. Complete characteristic data of the 18 RCA transistors and four semiconductor diodes are supplemented by equivalent circuits and dimensional outlines.

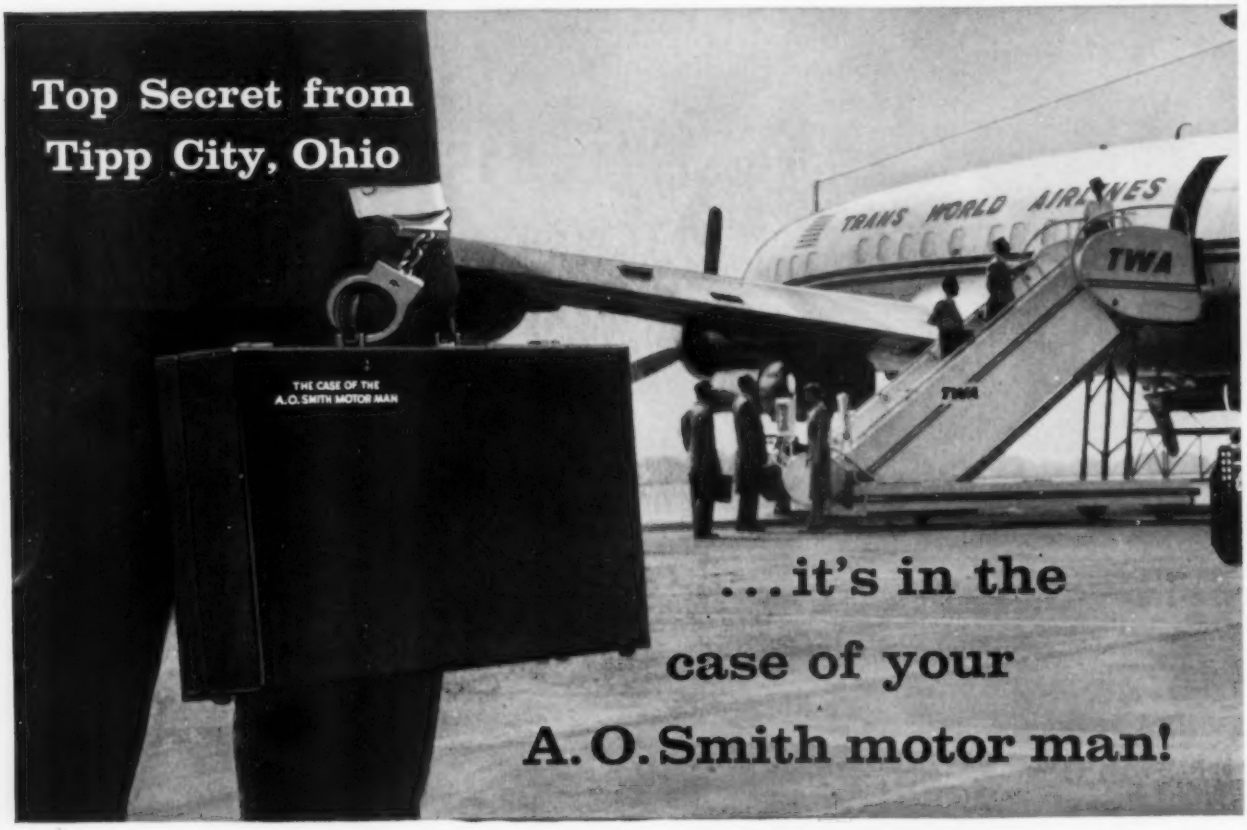
An Interchangeability Directory has been included to identify and describe many transistor types made by different manufacturers. The listings contain more than 500 type designations, including junction and point-contact types.

Fasteners Handbook

JULIUS SOLED, *P. E., Consulting Engineer, 6 x 9 in., 430 pp. Published by Reinhold Publishing Corp., 430 Park Ave., New York 22, N.Y. $12.50.*

This comprehensive coverage of industrial fasteners is a 'handbook' in the sense that it includes data on almost every type of standard and patented fastener available, including sizes and materials.

Descriptions, with photographs or drawings, are fairly complete and accurate. The author states that every description of a proprietary fastener



has been verified by its manufacturer. However, there is little evaluation done in guiding the reader to the best type of fastener for his application. Also, the fasteners of any one class, such as locknuts, are grouped alphabetically by their patented name, rather than by the type of locking device. The latter would have been more helpful to the experienced designer.

The book includes sections on rivets, inserts, screws, bolts, nuts, washers, pins, nails, metal stitching, quick-release fasteners, masonry anchoring devices and hose clamps.

Graphical Design of Bolted Flange Connections

Manual, 8½ x 10¾ in., 36 pp. Prepared and published by the Manufacturing Chemists' Association, Inc., 1625 Eye St., NW, Washington 6, D.C. $1.25.

A new manual sheet (M-1) covering "Graphical Design Procedure for Bolted Flange Connections (Lap Joints) Meeting ASME Code Requirements" can be used advantageously by engineering personnel and others associated with the design and

(Continued on page 187)

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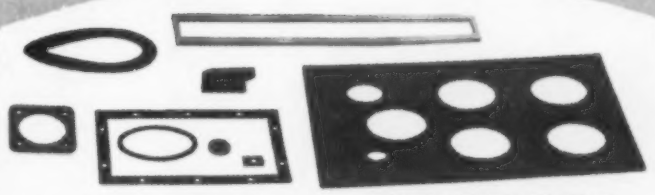

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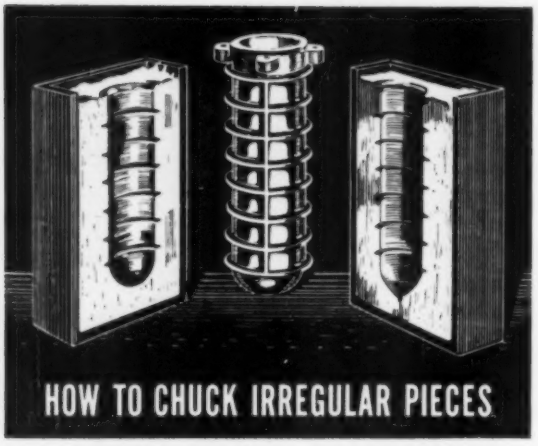

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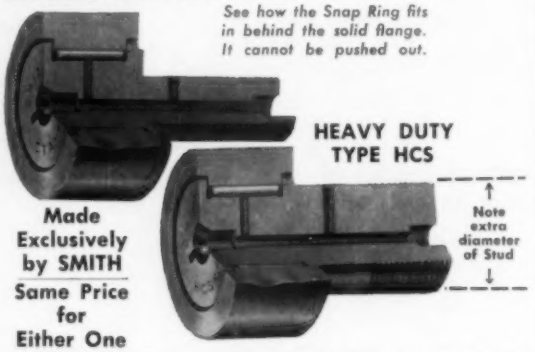

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Automatic Digital Computers

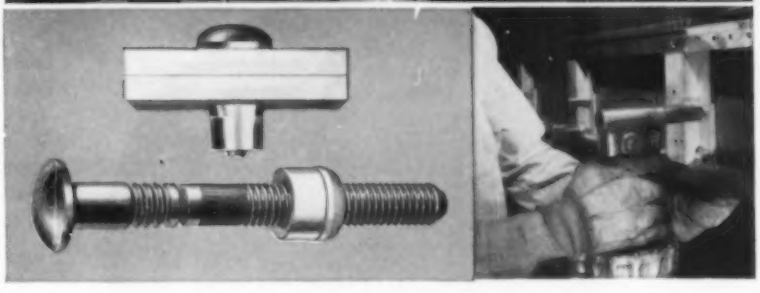
M. F. Wilkes, *F.R.S.*, 5¾ x 8¾ *in.*, 305 *pp. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N.Y.* $7.75.

Intended as a general introduction to the principles underlying the design and use of digital computers, this book covers logical design without going into the details of electronic circuit techniques. It also describes program construction and the methods by which the computer may be used to assist the programmer.

The first chapter is an excellent review of the development of automatic digital computers, with a careful distinction between these and analog machines like the Bush differential analyzer. Although the first automatic calculating machine was not finished until 1944, Charles Babbage had many ideas for such a machine over 100 years ago. His ideas are used to introduce the subject.

Later chapters cover logical design, program construction, relay computers, storage, circuits and computer design and operation.

"I can't understand all the complaining about lack of facilities in this department right after the board authorized the purchase of that new pencil sharpener."



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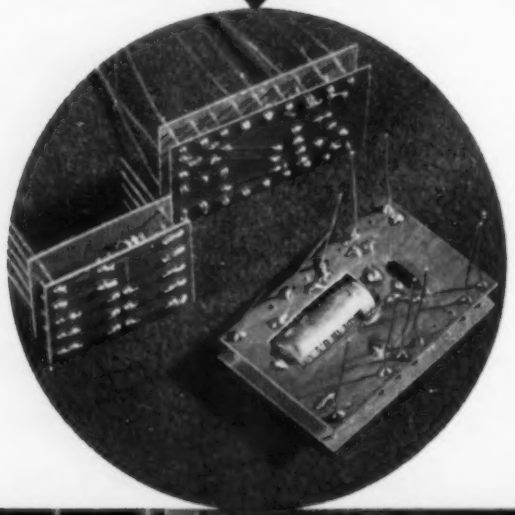

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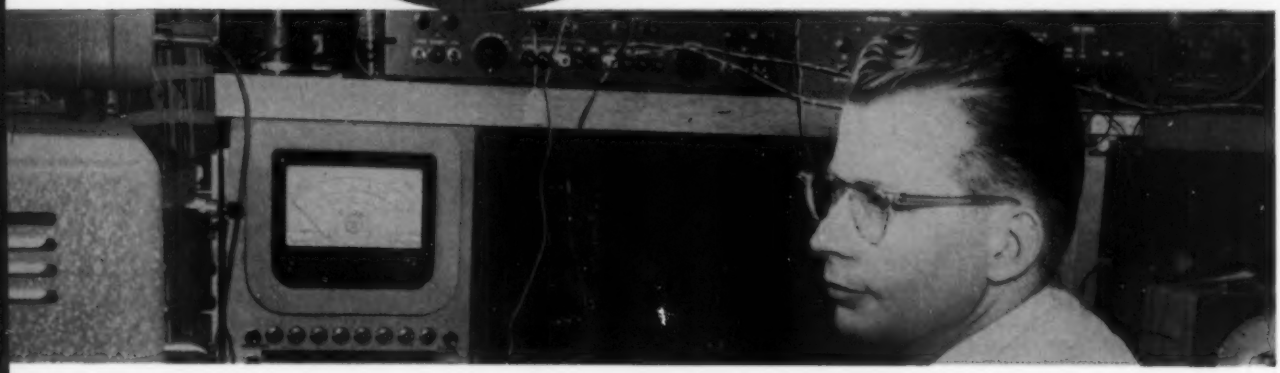

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For example: You can take an object made of a VYCOR brand glass, heat it to 900° C., and then plunge it into ice water *without* cracking, crazing, shattering, or any change in form.

Next, consider the freedom of design this tubing offers . . . and how little space it requires. (O.D. is ⅝".) With a tentative rating of 500 watts per linear foot, you can provide desired heat with short sections "banked," or long, single units.

These units heat up fast, too, going from room temperature to maximum rating within 5 seconds. The warm red coloring is right in the glass—it can't wear out or off. (Note: Specific shade depends on wattage input and varies from a deep red to a cheerful ruby glow—colors that add *psychological* value to the heat.)

Naturally, the glass enclosure protects the heating element from dirt, dust, and accidental shorting. Fire hazard is reduced to zero. And the heating element itself has a life rating of 5,000 hours, *plus*.

Not interested in portable heaters at the moment? How about laundry dryers, broiling units, baseboard heating, air conditioning, industrial dryers? Maybe you've already thought of other possible applications.

If you're interested in finding out more about this compact, attractive, versatile, and challenging item, contact our Appliance Parts Sales Department. Write, wire, or phone.

Afterthought: There are 7 different glasses in the VYCOR brand group. We have a booklet that tells about them, gives details on thermal characteristics, radiant energy control applications, and such. The booklet is Bulletin B-91. Free with the coupon.

On the level

This intriguing (though difficult to show to advantage) bit of gadgetry is part of a *turn-and-bank* indicator for airplanes.

We don't make such instruments. We do supply the glass tubing, made from one of our PYREX brand glasses.

Those who do fashion instruments of this type find Corning a reliable, economical source for this tubing. Besides being free from visual defects this tubing is rugged, accurate and easily worked.

Astute makers of many things have discovered the practical and profitable road to glass components. They bring their wants to Corning.

The list of items and special glasses involved almost defies enumeration. (There are some 65,000 glass compositions in our files.) But a good start is a pleasant book called "This is Glass." Free. And/or drop us a line briefing your problem and we'll investigate and report promptly.

How to prevent TV sunburn

Those who perform in front of TV cameras are occasionally subjected to an occupational hazard called "television sunburn."

Cause of this unsought skin tinting is the intense heat generated by the big lights used to illuminate sets.

Now set the stage for another problem: Telecasting during the *summer* from a barn-like structure that has defied every effort of those versed in the art of air conditioning.

This "*double trouble*" is what the producers of a popular show, called "Grand Ole Opry," faced last summer. Putting the show on from Ryman Auditorium in Nashville, Tennessee, loomed as quite an ordeal.

Enter here a sensitive and knowledgeable person. His suggestion: Try PYREX brand infrared reflecting glass.

Sheets of this glass were placed in front of the lights with simple brackets. Here's what the setup looked like:

Heat output was reduced some 50%. Yet this PYREX brand infrared reflecting glass still transmitted 75% of the wanted light.

Conclusion: Where there's a knotty problem you'll often find a Corning glass to solve it. A number of good examples are detailed in Bulletin PE-34, a concise reference on infrared, sight glasses, flat glasses and sundry other useful items. A check in the coupon brings it to you.

Corning means research in Glass

CORNING GLASS WORKS, 51-10 Crystal Street, Corning, N. Y.

Please send me the following material: Bulletin B-91, "VYCOR brand Industrial Glassware by Corning" ☐; Bulletin PE-34, "Corning Flat Glasses" ☐; Illustrated booklet, "This is Glass" ☐.

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ment of 95 oil cups of 29

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can probably save you money . . .

Even if your present fasteners are free!

Greater Design Flexibility
No need for access to both sides.

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Exerts as high as 600 pounds squeeze between parts.

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"POP" Rivets cannot back out or become loose. No lock washers or nuts required.

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Where space is important, "POP" Rivets' minimum head height is the answer.

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Designer wants holes tight, production wants holes larger. "POP" Rivets make both happy.

Least Back-Up Space
Strong, high grip "POP" Rivets need only enough back-up space to provide room for set head.

When buying fasteners, do you figure the *installed costs?* A fastener considered alone may cost very little but be very expensive by the time it's installed and becomes part of a finished product.

"POP" Rivets afford greater flexibility in product design. Often operations can be eliminated, assembly costs reduced, and speed of fastening increased.

Many users find high strength "POP" Rivets the most efficient and economical fastener for their product. Investigate its use in your application. Perhaps you too can enjoy the many advantages "POP" Rivets have to offer. Write us today.

"POP" RIVET DIVISION

UNITED SHOE MACHINERY CORPORATION
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OUR READERS SAY . . . . . .

Letters should be addressed to the Editor, *Product Engineering*, 330 W. 42 St., New York 36, N. Y.

Committee Chaos

To the Editor:

Your recent report on the tendency of designers to work in committees (May '57, p. 135) caused considerable consternation in our office. We felt (as did the men quoted alongside your editorial) that no better way of wasting time and threatening cordial friendship had ever been devised.

However, an article in the July 19 issue of *Metalworking Production* (England) by Norman Bashford and Dennis Meredith, has given us some second thoughts. The authors describe the redesign of a scrap-metal baling machine and how they and other members of the company coop-erated in true committee fashion.

It all started when "The general manager called a meeting . . . attended by the technical director, assistant general manager, chief draftsman, works manager, acceptance engineer, sales engineer, chief design engineer, purchasing officer and, in fact, every department head." The redesign was authorized, and to avoid a situation in which the work study and planning department were criticizing drawings after they were completed . . . regular weekly meetings "were set up so that suggestions were made as the design proceeded."

"This 'designing by committee' is not altogether desirable," the authors continue, "because it takes a long time . . . but it does produce results and there is less likelihood of criticism afterward . . . from our experience we would say that there is no better way of tackling the design of an *existing product.*" (my italics)

Now the principle begins to make sense. Everybody has something to contribute by way of improvement in a design they've been close to over a period of years. The different points of view insure that no facet of production or use will be neglected when analyzing for faults.

However, I feel (as do most of the

(Continued on page 195)

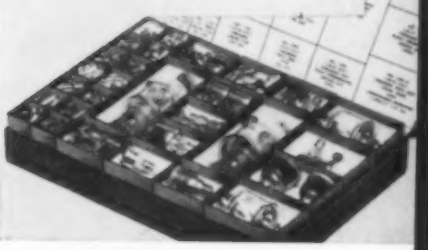
Design "Low Cost" Into YOUR Equipment

GITS

World's Largest Selection of Low-Cost Lubricating Devices

ment of 95 oil cups of 29 different types. Gits sales records show these oilers are most used for replacement and maintenance. Contents of each separate bin are clearly described on Inside Cover.

Special Introductory Price
Just $14.95 F.O.B. Factory
Satisfaction or your money back

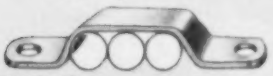


CLIPS FOR ATTACHING TUBING

When ordering, specify ¼", ⅜" or ⅜" tubes. Style TF.

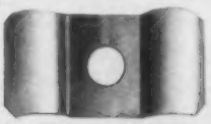
Single Clips

Double Clips

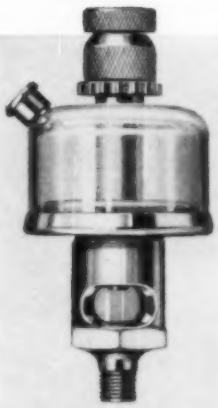


3-Tube Clips

4-Tube Clips



Double Clips — Wing Type



SIGHT GRAVITY FEED OILERS

Rate of oil flow regulated by needle valve, directly observed through sight glass in stem.

Shut-off knob does not affect needle valve adjustment. Visible oil supply. Non-breakable. Tops in convenience and dependability, at low cost. Style NFU—No. 3602-A.

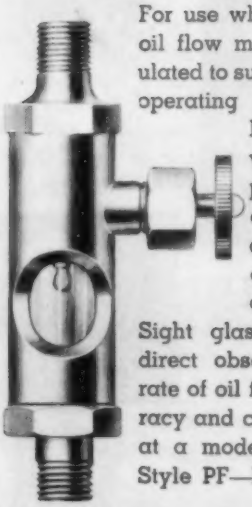
GEAR CASE GAUGES

This oil gauge plug permits instant checking of oil level within a transmission or gear case. For use where construction permits insertion in tapped hole. A valuable addition to any such equipment — at very low cost. Style BW—No. 4042.

SIGHT GRAVITY FEED MULTIPLE OILERS

This one unit replaces 3 to 8 individual oilers. Maximum practicality in a small central lubrication system. Positive cut-off during idle periods. Individual vibration-proof needle valve adjustments. With solenoid control (illustrated): Style MDS—No. 4685-A. Without solenoid: Style MD.

SIGHT GAUGES



For use where rate of oil flow must be regulated to suit changing operating conditions. Needle valve permits extremely accurate adjustment of oil feed. Sight glass provides direct observation of rate of oil flow. Accuracy and convenience at a moderate price. Style PF—No. 4290.

Don't price yourself out of the market. When you design proper lubrication into your equipment, specify GITS Lubricating Devices—the widest selection available anywhere. The items pictured above are only a few of our many thousands of lubricating devices. At the design stage, get the GITS story. Free Engineering Service. Send NOW for your free Catalog.

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FULL 42-INCH PRINTMAKING IN A CONVENIENT Table Model

Now, TABLE MODEL convenience, LOW COST and FULL WIDTH are combined in *one* whiteprinter—the new Ozalid Streamliner 200!

Now, anyone can turn out sparkling whiteprints in seconds—up to 42 inches in width! In the small office, the new Streamliner 200 gives you prints whenever you need them. For the large firm, it handles "rush work"... saves costly interruptions of volume printmaking... *stands by* when other machines are "down" for service.

Compact in design, Streamliner 200 stands just 22″ high... 38″ deep, with feedboard. Prints stack automatically. Controls are simple, easy to operate. Stand, shown above, is optional.

Why not test-run your own tracings through the Streamliner 200? Call your local Ozalid representative or write: Ozalid, Department O-10, Johnson City, New York.

A Division of General Aniline & Film Corporation
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First name in whiteprinting

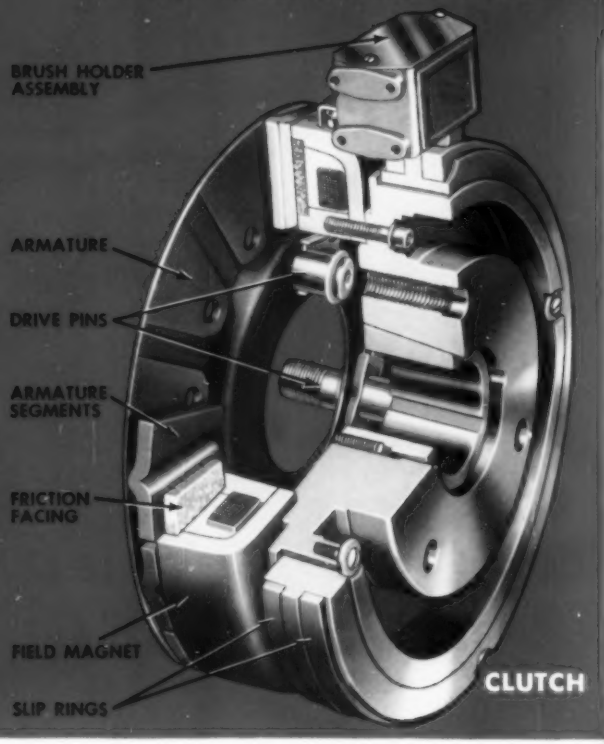
No. 4685-A. Without solenoid: Style MD.

Clip this page for handy "rough reference"

The New EATON Dyna-torQ

MAGNETIC-FRICTION CLUTCHES, BRAKES, CLUTCH-BRAKES, CLUTCH-COUPLINGS

Are the Accurate, Trouble-Free Means of Controlling Power and Motion in Modern Stop-and-Go Machines

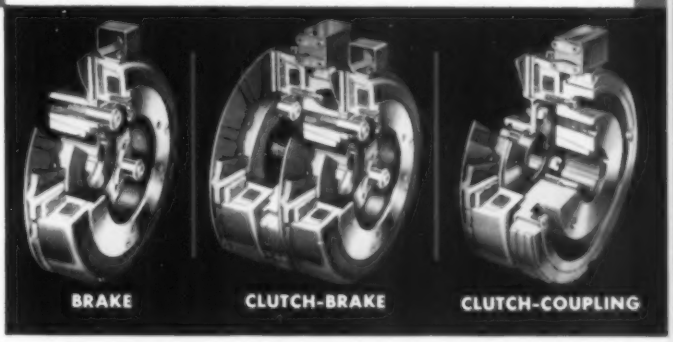


The Eaton Dyna-torQ electro-magnetic friction units include a number of unique design advancements which provide longer life and superior performance with less maintenance. Check the following important advantages:

1. **Extremely Rapid Response in Clutching and Braking**—makes Dyna-torQ units ideally suited to a wide range of manual and automatic cycling applications.
2. **Smooth, Shockless Engagement**—permits rapid operation without backlash or chatter.
3. **Highly Effective Cooling**—maintains lower operating temperatures; permits fast, repetitive actuation.
4. **Self-Adjustment**—automatically maintains proper clearance between armature shoes and field magnet.
5. **Simple, Accurate Control**—manual or automatic; may be had to operate on 110, 220, or 440 volt, 60 cycle, alternating current.
6. **Low Maintenance Costs**—result from unique design features and superior quality of construction, assuring long operating life and minimum down-time.

Eaton Dyna-torQ Clutches and Brakes are electrically operated, disc-type friction units having two basic components: a field magnet and an armature. Torque is transmitted as the magnet pulls the armature into engagement. Because the pull of the magnet is direct without intricate linkage, and the movement of the armature is slight, Dyna-torQ units are capable of extremely rapid response in clutching or braking.

Ask us to tell you how these Dyna-torQ units will fit your equipment.



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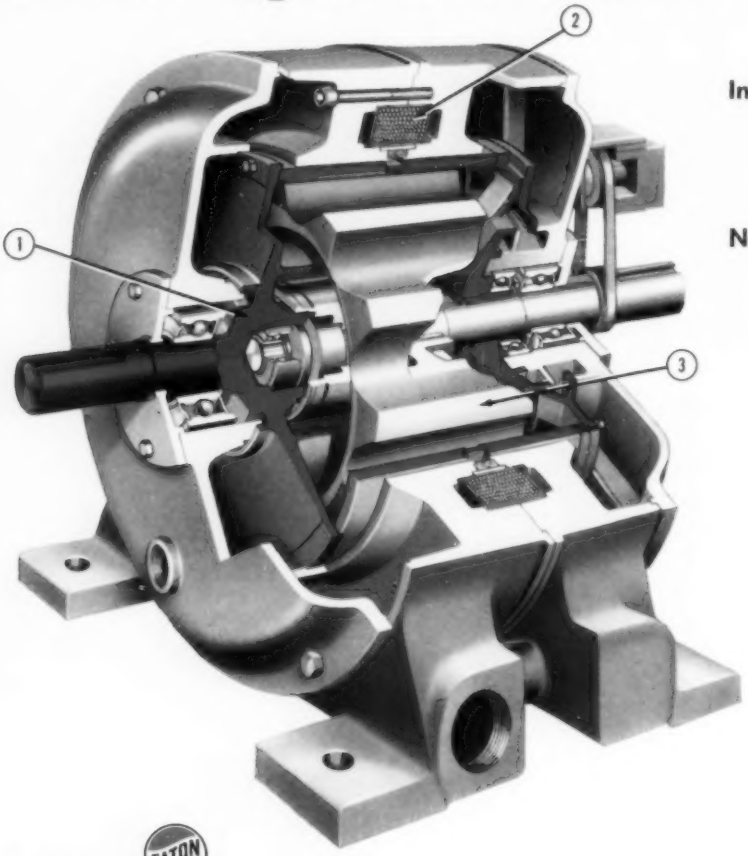

Infinitely adjustable speed from AC power source

★

Wide speed range

★

No commutators, rings, brushes, or rotating coils

★

Instantaneous response

★

Remote control

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Low power losses

★

Quiet, efficient operation

★

Simple construction

★

Low maintenance cost

1. Input Drum Assembly
2. Stationary Field Assembly
3. Output Rotor Assembly

EATON

DYNAMATIC®

Eddy-Current Equipment is the Answer!

Dynamatic Eddy-Current Drives, Couplings and Brakes are the solution to difficult speed control problems—in both original equipment and factory installations. Smooth, stepless acceleration and deceleration are achieved without mechanical contact between rotating members. Eddy-current braking provides cushioned, controlled stops. Dynamatic electronic or magnetic amplifier controls, in conjunction with these units, assure wide latitude in operating functions. For efficient, economical speed control, investigate Dynamatic Eddy-Current Equipment.

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Illustrated Literature Describing
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EATON MANUFACTURING COMPANY
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responsible people here) that new ideas, new products and radical departures from custom will always be delayed, watered-down and ultimately die (with satisfied "I told you so" looks) without issue if subjected to the torture of a committee.

—JOHN GORDON
Chicago, Ill.

ED—One quote we missed in Mr. Gordon's letter might underline his doubts:

"Could Hamlet have been written by a committee, or the Mona Lisa painted by a club? Could the New Testament have been composed as a conference report? Creative ideas do not spring from groups. They spring from individuals. The divine spark leaps from the finger of God to the finger of Adam."—A. WHITNEY GRISWOLD, *president of Yale, to '57 graduating class.*

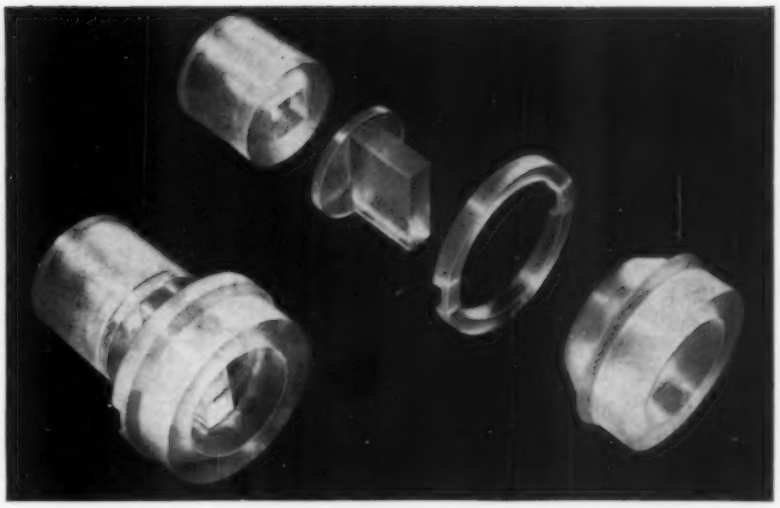
The Salary Problem

To the Editor:

Whenever salary curves are published nationally, I am sure there is a natural tendency for an individual almost immediately to spot himself mentally on the chart. Most engineers naturally will discover that they lie well below the 10th or 25th percentile lines. Half of the engineers will discover they lie below the 50th percentile line. The latter surely will have the immediate reaction, "You mean my company considers me a below-average man?" Since very few people

(Continued on page 199)

"Your job is to design it, Medflea, not to carp about what it's going to cost the taxpayer."



prove it works **before** you go into production

Machine that part from polystyrene and let us investment-cast it in the metal you plan to use. Test it and, if some change is indicated, repeat the process until you have the final answer. This cut-and-try method of proving a design and an alloy saves you a lot of time and money.

Polystyrene machines readily and is inexpensive. Complex patterns can be made in sections and assembled, then cast as a unit just as they'd be investment-cast in quantity. Thus parts for testing are exactly like you'll get in production, but they cost far less than cutting them out of metal.

Technical Data Available

When your idea is on paper, but before you start to make the polystyrene patterns, send us a blueprint. We'll figure the shrinkage factor for you, suggest possible gating arrangements and design modifications which may effect further economies.

The pamphlet, *A Guide for Making Polystyrene Patterns*, describes methods of machining and names sources from which this material can be obtained. For a free copy, write Precision Metalsmiths, Inc., 1079 East 200th Street, Cleveland 17, Ohio.

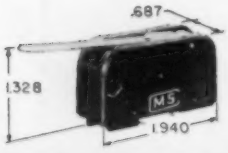
pour yourself an assembly with
PRECISION METALSMITHS, Inc.
Investment Castings

MICRO SWITCH Precision

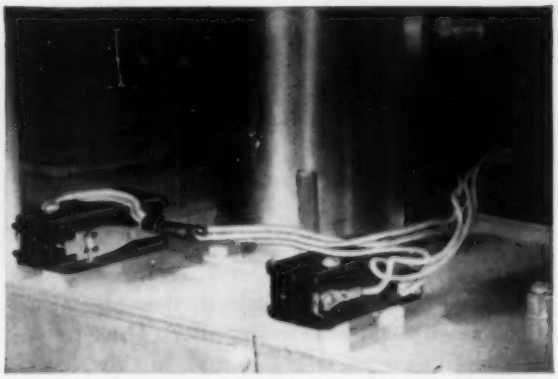
...FIRST IN PRECISION SWITCHING

Six Examples OF HOW DESIGNERS OF A WIDE VARIETY OF PRODUCTS USE MICRO SWITCH PRECISION SWITCHES TO SIMPLIFY AND IMPROVE PERFORMANCE

Switch-controlled automatic coffee brewer adds 22 cups to the pound

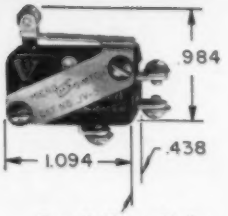


These lever-actuated switches control every step



"Our coffee brewer would have been impossible without these MICRO SWITCH precision switches," says the head of a concern which makes automatic brewers for coffee vending machines. Photo shows three of seven switches which control every step of the brewing process. Precision switch operation produces 22 more cups of excellent coffee to the pound. MICRO SWITCH general purpose basic switches offer a wide variety of actuating means and operating characteristics. The actuators, like the rigid lever type shown, are constructed as an integral part of the switch. (*Catalog 62*)

Throttle control switches centralize jet pilot's handling of many functions



Small V3 switches with high electrical capacity

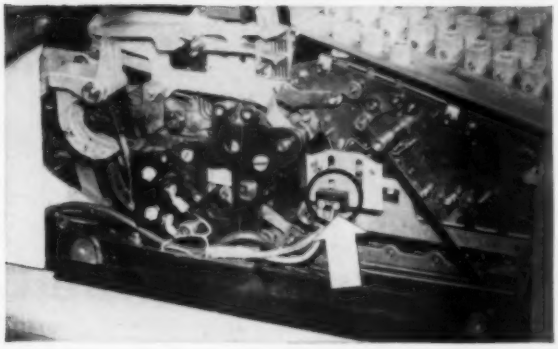
This throttle control, equipped with MICRO SWITCH precision switches, gives a jet plane pilot the utmost centralized control possible. Photo shows a throttle control quadrant with three MICRO SWITCH V3 switches which "allow a mechanical perfection comparable to a fine watch," according to the designer. MICRO SWITCH V3 switches have the highest electrical capacity for their size of any switch available. They have been developed to meet the exacting requirements of designers for an extremely small switch with no sacrifice of quality or precision. V3 switches are available in a wide variety of terminal designs, contact arrangements and operating characteristics. (*Catalog 74*)

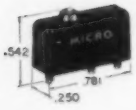
Send for catalog 62 on Basic Switches

MICRO SWITCH can help your research and development program. There are always new switches at MICRO SWITCH. Call the nearest branch for technical engineering assistance.

Send for catalog 83 on Enclosed Switches

Switches have uses unlimited





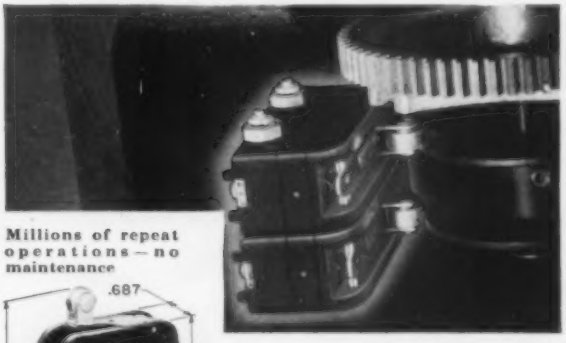
Each key connects with a subminiature switch

45 switches actuate intercoupler device to speed tabulation of accounting information

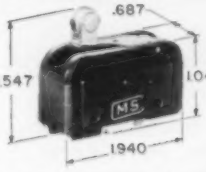
This device couples such a machine as a cash register, for instance, with a card-punching machine to record accounting data. "Small size of MICRO SWITCH subminiature switches make them efficient, reliable and an 'ideal package'," say the designers. "MICRO SWITCH technicians keep us posted on up-to-date developments and make our research and development work easier." (*Catalog 75*)

MICRO SWITCH nerve centers help automatic camera take a photo every five seconds

MICRO SWITCH precision switches trigger all phases in the operation of an automatic camera. Despite the delicate functions of the switches, these units require a minimum of maintenance. In fact, the maker is now overhauling one that has logged over 65,000 photos. "MICRO SWITCH units," says the designer, "offer better quality and more dependability." (*Catalog 62*)

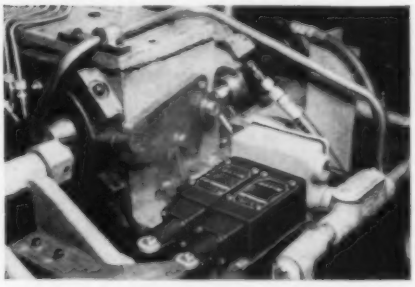


Millions of repeat operations—no maintenance



Roller-lever actuated switches control operating cycle

Switches hold abrasive wheel true while cutting discs as thin as .0145 in.



MICRO SWITCH TYPE ML Switches are key controls of this equipment

An abrasive wheel wears down while cutting, constantly decreasing in diameter. One of the switches used on this cutter keeps the wheel at a constant distance from the rod center. "MICRO SWITCH precision switches enable us to cut high nickel alloy rods to extremely critical tolerances," say the designers. The switches control the complete feeding and cutting cycle. The two MICRO SWITCH ML switches shown combine rugged construction with precision, snap-action switching. (*Catalog 83*)

Switches do "thinking" and this machine out-produces battery of drill presses

With MICRO SWITCH precision switches actuating the various operating steps of this turret drill, one operator can keep three or four machines at work. Main advantage of the use of MICRO SWITCH units, according to the designer is simplification of controls. This factor means that one setup can perform six to eight jobs. "We build a high quality machine and we demand high quality components," he says. (*Catalog 62*)

MICRO SWITCH

A DIVISION OF MINNEAPOLIS-HONEYWELL REGULATOR COMPANY

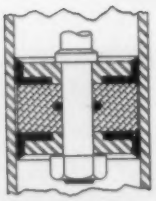
In Canada, Leaside, Toronto 17, Ontario • FREEPORT, ILLINOIS

Redesign

with

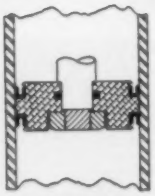
PALMETTO® U-RING

for
low cost
and
low friction



BEFORE

. . . double acting piston assembly with standard molded cup packings.



AFTER

. . . same application using PALMETTO U-Ring.

Engineers designing hydraulic and pneumatic cylinders are finding that PALMETTO U-Rings permit the use of low-cost, one-piece pistons in place of expensive, multi-part designs, with no sacrifice of efficiency. In fact, the one-piece piston with PALMETTO U-Rings is superior because it cannot loosen up, is easily assembled and serviced, and saves weight and space.

PALMETTO U-Rings seal with extremely low friction because they float freely in the packing groove. There is no opportunity for binding due to overcompression. Synthetic and fabric reinforced compositions in similar sizes allow interchangeability for high or low pressure service. The PALMETTO U-Ring is doing an exceptional job in the hydraulic equipment of many well-known manufacturers. Ask us how it can be used in your piston design to cut costs.

Rugged rectangular design PALMETTO U-Rings increases stability and eliminates rolling in the groove. Wide-lipped flare makes it suitable for use in cylinders made from commercial tubing honed up to .030 over nominal sizes.

For information on other PALMETTO packings and how they can help you simplify your design, please write.

PALMETTO Packings

packing more performance into every application

GREENE, TWEED & CO.

NORTH WALES, PENNSYLVANIA

How to keep informed on the "with what" part of your business

AT YOUR FINGER TIPS, issue after issue, is one of your richest veins of job information – advertising. You might call it the "with what" type – which dovetails the "how" of the editorial pages. Easy to read, talking your language, geared specifically to the betterment of your business, this is the kind of practical data which may well help you do a job quicker, better – save your company money.

Each advertiser is obviously doing his level best to give you helpful information. By showing, through the advertising pages, how his product or service can benefit *you* and *your* company, he is taking *his* most efficient way toward a sale.

Add up all the advertisers and you've got a gold mine of current, on-the-job information. Yours for the reading are a wealth of data and facts on the very latest in products, services, tools . . . product developments, materials, processes, methods.

You, too, have a big stake in the advertising pages. Read them regularly, carefully to keep job-informed on the "with what" part of your business.

McGRAW-HILL PUBLICATIONS

like to think they are below average, then the next thought may be, "Or is my company below average?" Either thought breeds dissatisfaction in a world where half of all the men and half of all the companies are by definition below average. Since there is no escape from this fate, it seems to me to be inadvisable to publish such surveys, lest we prompt individuals to leave their jobs and commence an unhappy pot-of-gold search for "that other half."

Surveys, of course, are essential. But they should be confidential documents for management to use in maintaining fair salary administration. The common practice of displaying the data in so-called "maturity curves," even when separated into percentile groups, is quite misleading. I, for one, would like to see a separate chart drawn for each of the levels of responsibility. Each chart would show three curves: the 25th, 50th, and 75th percentiles, as a function of years since B. S. degree.

The levels of responsibility would be as follows:

Position	Experience Qualification Beyond B. S.	General Responsibility
Junior Engineer	0	Beginning
Engineer	1–3	Minor Part of a Project
Senior Engineer	3–5	Major Part of a Project
Project Engineer	5–9	All of a Major Project
Division Engineer	9–15	Series of Major Projects

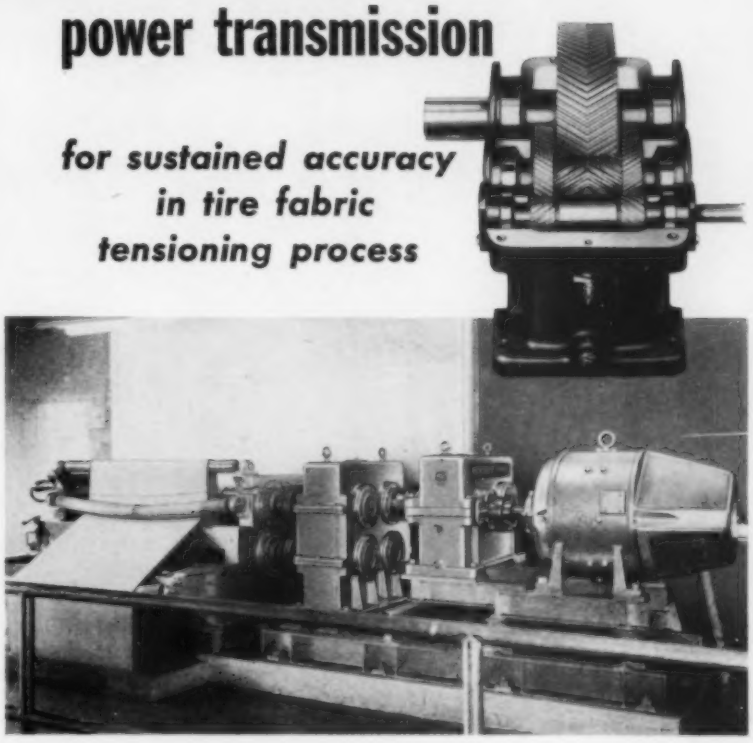
All executives at higher levels (including chief engineers) would be excluded from the survey.

In the article "Are You Paid What You're Worth," (March '57, p 140), Dr. Peck proposed a formula which resulted in a set of hypothetical salary growth curves. I do not see that a formula does anything special for us. The facts as they actually exist around us are the only important things. The sets of curves I propose above would truly represent the existing facts, and would achieve the real purpose of a salary survey. This purpose is simply to have all the information at hand so that your company may keep in step. Since there is no absolute scale to which engineering salaries can be compared, then we must do the best we

(Continued on page 202)

Waldron selects H & S power transmission

for sustained accuracy in tire fabric tensioning process

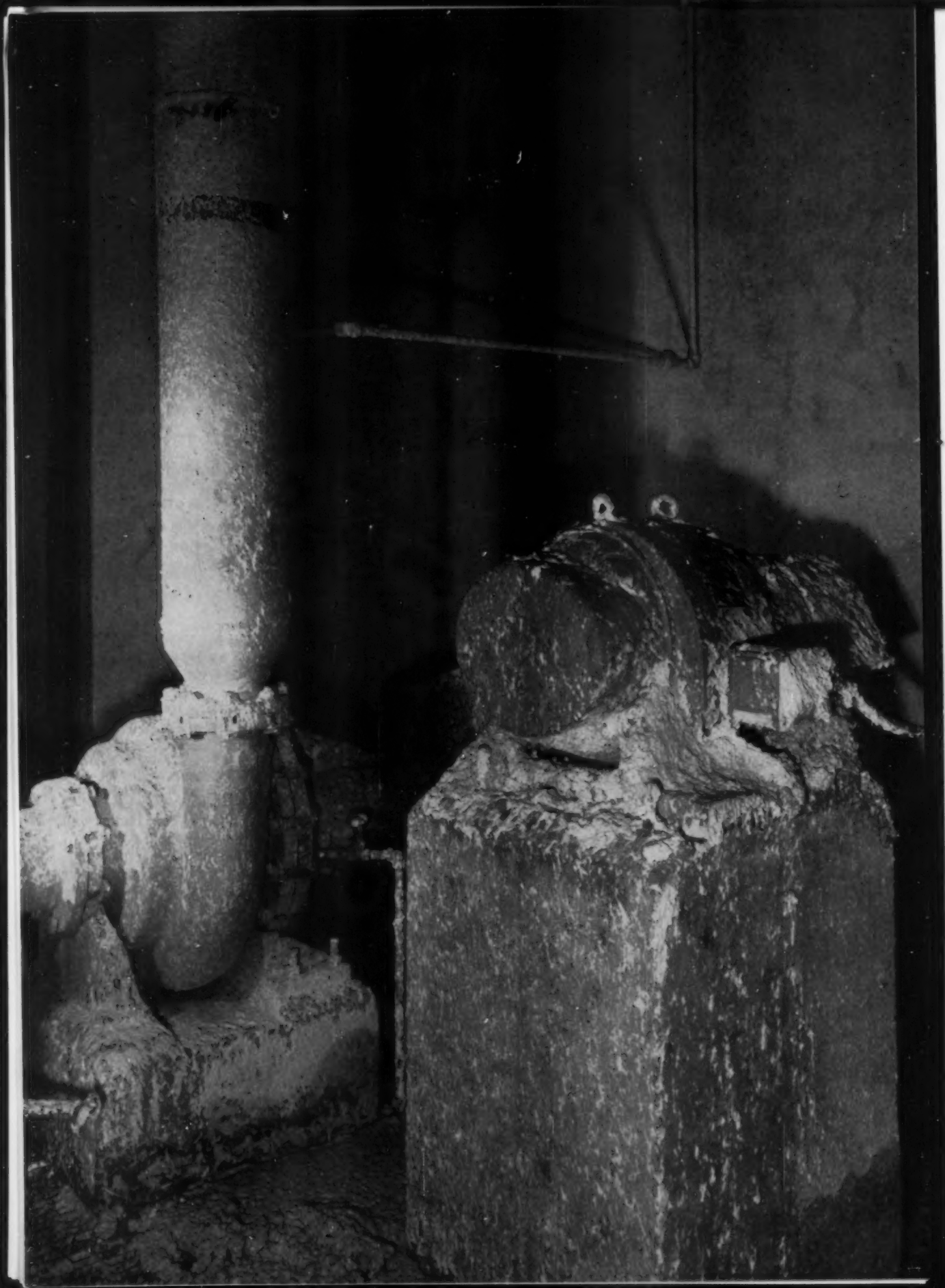


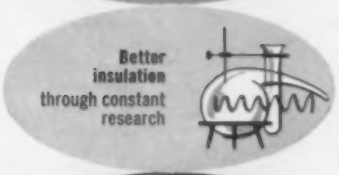
Today's rugged, heavy-duty tires call for extra measures in manufacturing to insure dependability and longer life. An important process at Goodyear Tire and Rubber Company is this Nylon Tire Cord Unit designed and built by the John Waldron Corporation, New Brunswick, N. J. Its function is to apply tension to the basic Nylon cord fabric before it is calendered with rubber—a process that limits "growth" to an acceptable minimum when tires are in use.

Essentially a stretching process that takes place while the fabric moves at a fair rate of speed, exacting power requirements must be maintained. A double reduction herringbone H & S speed reducer was recommended by H & S engineers, to be energized by a 150 H.P. motor. Power is then distributed to the tensioning machine rolls by a special H & S four shaft roll drive.

Here's an important job for which H & S equipment is well suited. The use of anti-friction bearings throughout, generous size of shafts, gears and housings, and accurate machining to close tolerances assure long life and completely satisfactory performance. Consult your H & S representative or write us, for help in selecting Speed Reducers, Roll Drives or precision gears of many types—for dependable power transmission.

THE HORSBURGH & SCOTT CO.
GEARS AND SPEED REDUCERS
5112 Hamilton Avenue
Cleveland 14, Ohio





Be glad you weren't working here...

But this sturdy Louis Allis motor was, and still is!

Shortly before this picture was taken, that pulp-mill pump suddenly ruptured. Blasted every object in the area with a thick coating of hot paper pulp.

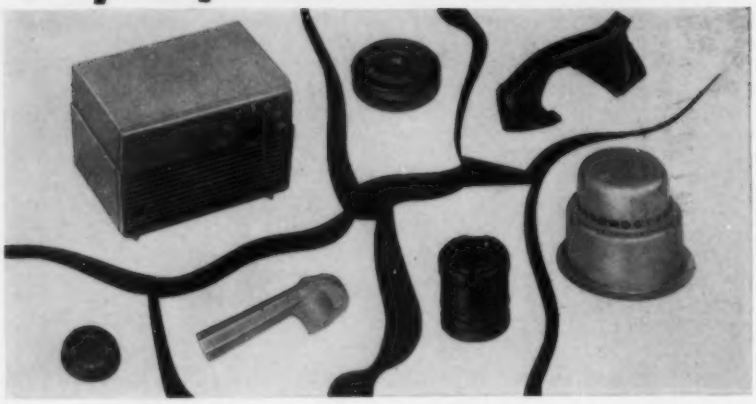
But note the Louis Allis 20 HP splash-proof motor designed to take this kind of abuse — and come back for more! Note that it took the full force of this blast on its vented *underside* — a motor's most vulnerable point. Only a sturdy, well-designed motor could resist this. Still functioning perfectly this one didn't miss a beat!

Let us tell you more about Louis Allis electric motors. About such unique features as the new varnish of Gilsonite combined with phenolics and alkyds that provides the highest degree of moisture, acid, and alkali resistance . . . locked bearings that reduce end play and extend bearing life . . . the dynamically balanced rotor. And about the many other Louis Allis extras better discussed at length in our file-sized Reference Bulletin 1700. Why not write for it today? The Louis Allis Co., 458 East Stewart Street, Milwaukee 1, Wisconsin.

LOUIS ALLIS

MANUFACTURER OF ELECTRIC MOTORS AND ADJUSTABLE SPEED DRIVES

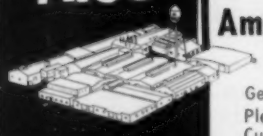
Why Buy Plastics Piecemeal?



Let AICO Produce All Your Parts

A veritable super market of custom molded plastics, Aico's one-stop shopping service provides you with the complete solution to all plastics problems. Aico's wide experience with every type of molding material and modern facilities for all molding methods eliminates split responsibilities . . . can save you time, money and worry.

AICO



Aico's complete plastics molding service includes Engineering, Mold Building, Compression, Transfer, Plunger, Injection and Cold Molding . . . plus the molding of Reinforced Fiberglas.

Mail coupon for the solution to your current custom plastic molding problem.

American Insulator CorporatiOn

New Freedom, Pa.

Gentlemen:
Please send me additional information on Aico's Custom Plastic Molding Service.

Company Name .....
Individual .....
Title .....
Address .....
City ..... State .....

☐ Have Aico representative call on me.

can, and compare them to what everyone else is doing. This is the firmest ground for a truly fair salary administration program.

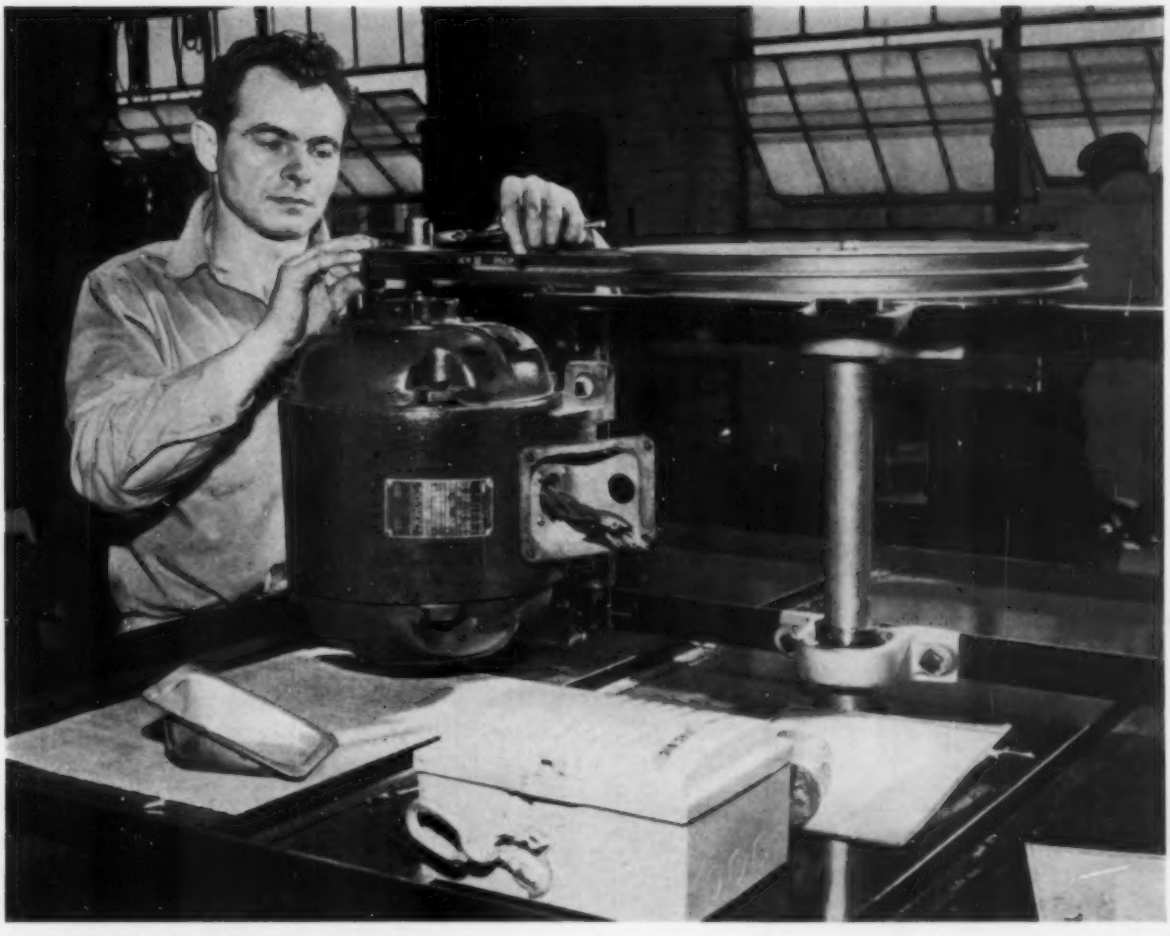
Nondegree Engineers

Finally, I would like to see a survey which shows the national consensus on the status of the nondegree man. I suspect there may be more fundamental agreement on this point than I have ever seen admitted in a published article. I suspect the agreement goes something like this: "We admit that the nondegree man can be just as useful and capable as the degree man, and is, therefore, fully deserving of the associated rewards; however, we must not admit this publicly, for fear we may somehow contribute to the lowering of the standards for engineers."

The solution to this problem seems fairly simple. To begin with, we surely should not allow the title "Engineer" to be used by someone who is not capable of doing engineering work. This capability almost always can be achieved only through a certain amount of formal education. Therefore, a basic qualification for promotion to an engineer classification could be a demonstrated proficiency in basic engineering subjects, such as math (not necessarily including calculus), physics, strength of materials, engineering materials and processes, and so on . . . whatever is appropriate to the particular activity. Completion of a series of evening courses would then qualify a man for promotion, and prevent the discouragement of a high-caliber, but degreeless man.

—John D. Kemper
Marchant Calculators, Inc.

"It's something we ordered special for you . . . an eraser with a pencil tip."



AT PENN VENTILATOR COMPANY

DIEHL motors increase product dependability

Operating dependability is an inherent feature of the power-roof ventilators made by Penn Ventilator Company, Philadelphia, Pa. Usually, these ventilating units are installed in locations completely exposed to the elements and relatively inaccessible for regular servicing. Failure in operation, however, could halt an important manufacturing operation or even cause complete plant shut-down. Hence, every detail in the design and construction of Penn Ventilators is considered with a view to the assurance of uninterrupted operation for long periods of time with a minimum of maintenance.

This is one of the reasons why Penn Ventilator Company has consistently selected DIEHL motors for its equipment. James T. Ellington, Penn Director of Purchases says: "We can't gamble with an inferior unit—a reliable motor is a necessity! DIEHL motors are trouble-free and well suited to all our requirements."

Here is another example of how DIEHL has cooperated with a progressive manufacturer to build a product of highest quality and proved reliability. With almost three quarters of a century of experience in the design and manufacture of motors, DIEHL is well equipped to help you solve your motor problems. We'll work closely with you to provide the right motor —at the right time—at the right price.

Diehl

DIEHL MANUFACTURING COMPANY
Electrical Division of
THE SINGER MANUFACTURING COMPANY
Finderne Plant, SOMERVILLE, N. J.

☐ Please send me Consolidated Motor Catalog and Price List No. PE 10 3540

☐ Please have a DIEHL representative call

NAME_____
COMPANY_____
STREET_____
CITY_____ ZONE_____ STATE_____

Baltimore • Chamblee, Ga. • Charlotte • Chicago • Cincinnati • Los Angeles • Milwaukee • Needham, Mass. • New York • Philadelphia • Syracuse

ACP Granodine® IS THE BASE FOR SPARKLING, DURABLE PAINT FINISHES ON HOME APPLIANCES

ACP GRANODINE IN HOMES—ranges, refrigerators, freezers, washers and dryers, and many other appliances have sparkling, durable finishes anchored to the metal by ACP Granodine nonmetallic phosphate coating.

ACP Granodine anchors the finish on many home appliances, giving them a sparkling and lasting beauty. It performs the same function on automotive equipment and industrial products by chemically converting steel surfaces to a nonmetallic phosphate coating. It not only greatly increases the adhesion of the finish, but also provides extremely good corrosion resistance, even when used in conjunction with a relatively thin and flexible paint film. Granodine coatings are easily and economically applied to steel surfaces by dipping, spraying or brushing.

AN AUTOMOBILE FINISH must retain its beauty under all weather conditions. ACP Granodine greatly increases the adhesion of the paint to the metal, provides an excellent base for such a finish.

ACP GRANODINE IN INDUSTRY—drums, materials handling equipment, machine tools and many other steel products throughout the plant are protected by a Granodine base which firmly bonds the paint.

LEARN MORE ABOUT ACP GRANODINE. Bulletin 1380 describes the various types of ACP Granodine and gives information which will help you select the proper one for your particular application. Write for your copy today.

CHEMICALS ACP PROCESSES

AMERICAN CHEMICAL PAINT COMPANY, Ambler 17, Pa.

DETROIT, MICH. • ST. JOSEPH, MO. • NILES, CALIF. • WINDSOR, ONT.

New Chemical Horizons for Industry and Agriculture

MOLY NEWS

CLIMAX MOLYBDENUM COMPANY, 500 FIFTH AVENUE, NEW YORK 36, N. Y.

Ultra-Strength Steels Boost Tensile Strengths to 300,000 psi.

Ten years ago, engineers considered 180,000-psi tensile strength in steels the maximum they could use safely.

Today, alloy steels with minimum strengths of 220,000 to 300,000 psi are being used commercially. These ultra-strength steels have the ductility and toughness needed for structural applications. At tensile strengths above 220,000 psi, they show more strength per pound of product than high-strength aluminum alloys. And at 260,000 psi, they are approximately 15% lighter than aluminum alloy products of the same strength.

Molybdenum is an essential element in almost all of these steels.

How are the higher strengths and strength/weight ratios of these steels being used? Until recently, they've been utilized almost exclusively in aircraft components, such as landing gear. Now, however, they're being considered wherever weight and space savings compensate for higher fabrication costs . . . as, for example, in equipment that must be moved (portable tools); gears, pulleys, belts, liners; heavy machinery operating at high stresses; machinery where inertia is a design factor; materials-handling equipment, such as cranes; and transportation equipment.

Like to know more about ultra-strength steels and their properties, and the names of manufacturers? For our free booklet, circle #1 on the coupon.

Bulletin Shows How to Get Heat Resistance in Cast Iron

In cast iron, heat resistance can mean different things: resistance to growth, to heat checking, to scaling, or to deformation under load at high temperatures.

"Why Moly Iron? #5" contains a chart showing the specific kinds of heat resistance needed by parts such as brake drums, melting pots, piston rings and so on. This chart also lists the best type of iron to use and the proper alloy additions. A number of detailed case histories document this useful bulletin.

For a free copy of "Why Moly Iron? #5" circle #2.

New Coatings May Solve Moly's Oxidation Problem

The most important obstacle to using molybdenum at high temperatures is being overcome. Oxidation is the problem; at temperatures over 1000F, molybdenum oxidizes rapidly.

Newly developed coatings offer molybdenum the needed protection. Three types are promising:

1. Electro-deposited chromium and nickel layers which protect molybdenum to 2000F.

2. Sprayed coatings of aluminum-chromium-silicon alloys, and nickel-boron alloys, which have proved effective at 2000-2400F.

3. Ceramic and molybdenum disilicide coatings which hold promise of protecting molybdenum from oxidation at even higher temperatures.

Digested from "Protecting Molybdenum at High Temperatures" by Julius Harwood, Materials & Methods. For reprint of entire article, circle #3.

Booklet Deals with Molybdenum Joining Techniques

Recent progress in joining molybdenum, and suitable means for protecting it from oxidation, are opening up new uses for molybdenum and its alloys in structural components for high-temperature service.

"A New Look at Joining Molybdenum" by R. R. Freeman and J. Z. Briggs, both of Climax, analyzes the factors involved in joining moly and discusses the methods available.

For the free booklet, circle #4.

List of Moly Literature Now Available

Copies of more than 30 recent pieces of technical literature on molybdenum are available from Climax Molybdenum Company. *For a free list of these, including titles, authors, sources and 25-30 word summaries, just circle #5.*

Steels for Power-Plant, Refinery Equipment at 900-1100F

Designers of power-plant and refinery equipment who need to select steels for applications at 900 to 1100F will be interested in a copy of "Chromium-Molybdenum and Chromium-Molybdenum Vanadium Steels for power-plant and refinery service up to 1100F."

This paper, presented at the ASME annual meeting by George V. Smith, Bard Professor, Cornell University, appraises literature on the subject and draws some new, objective conclusions.

For a free reprint, circle #6.

New Climax Alloy Proves Unusually Wear Resistant

These liner castings, made of Climax 321, proved highly resistant to wear in our ball mill discharge launders. Severe wear normally occurs in this operation as a result of erosion from the coarse pulp flowing out of the ball mill discharge.

If you need a highly wear-resistant material, you may be interested in our new Climax 321 Alloy. It's a hard, martensitic type of white iron containing nickel, chromium and molybdenum in proportions that are well balanced, both metallurgically and economically.

We've been using 321 Alloy in our own mining operations with exceptional results. Comparative tests in ball mill liners and grinding balls proved its excellent wear-resisting properties.

Because this alloy is relatively new, service results in other applications are not yet available. However, our laboratory studies and data indicate it should prove suitable for the general run of abrasion-resistant castings of the martensitic white iron type—such as wear shoes, sand and dredge pump wearing parts, pug mill knives, mixer liners, etc.

Climax 321 can be melted in a cupola or electric furnace and cast in either sand or permanent (chill) molds. It has a normal hardness range of 55 to 62 Rockwell "C".

Composition: Carbon 3.30-3.60%; Silicon 0.30-0.60; Manganese 0.50-0.80; Nickel 2.75-3.25; Chromium 1.75-2.25; Molybdenum 0.70-1.10; Sulphur 0.15 max.; Phosphorus 0.30 max. *For data sheet, circle #7.*

Climax Molybdenum Company, Dept. 61
500 Fifth Avenue, New York 36, N. Y.

I'd like more information on:

1 2 3 4 5 6 7

Name_____

Company_____

Address_____

City_____

If your VACUUM or PRESSURE requirements are in this range

Vacuums to 27" Hg.
Pressures to 20 psig.
Displacement:
3.6 to 7.2 c.f.m.

. . . save space - - simplify mounting - - eliminate troubles - - improve operation

with

LEIMAN
Integral Rotary
AIR PUMP and MOTOR

MODEL K. 3.6 c.f.m. ½ hp.
13½" long - - 12" wide - - 7" high

MODEL K3. 7.2 c.f.m. ½ hp.
16" long - - 15" wide - - 9" high

- Steel wings for long wear
- Automatic Wing Adjuster
- Automatic oiler—requires filling only once in 60 to 80 hours.
- Ball bearings for quiet running
- Bearing grease cups need checking only once in 90 days
- Fan cooled—may be run 24 hours a day, 7 days a week
- Automatic thermal overload motor protection
- Noiseless operation
- Inlet filter and outlet separator
- Oil-free air

Automatic Wing Adjuster
Patented Leiman feature adjusts automatically, pushes steel wings into contact with cylinder wall, assures constant seal, prevents wings from sticking or binding.

•

Write for detailed folder and 12-page catalog showing many other Leiman pumps.

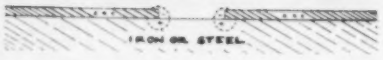
LEIMAN BROS, Inc.

107 Christie Street, Newark 5, New Jersey

Cut Galvanizing Costs as much as 75% with

ZINC RICH COATING ®

Z.R.C.



If you buy galvanizing—or if you have a product that can be improved by galvanizing you can get galvanic protection against rust and rust creepage via Z.R.C. for as little as 1½¢ per sq. ft.

And because Z.R.C. is easily applied by brush or spray (small pieces may be dipped) you can galvanize iron or steel surfaces of any size anywhere.

Z.R.C. is a free-flowing compound consisting of 95% pure zinc—dries quickly to a tough, flexible, firmly adherent coating—can be built up to any thickness. No special mixing or surface preparation is necessary. Protection begins on contact and lasts (Z.R.C. will withstand over 3000 hour salt spray testing). For prices, details and ordering information . . .

the SEALUBE company

14 Valley St., Wakefield, Mass.

IF THIS IS YOUR PROBLEM

If you need effective, highly readable, smartly illustrated company literature (booklets, pamphlets, manuals) to display your products, inform the public of your operations, attract key personnel to your plant, train employees, and perform any of the other communicative functions that are vital to your business . . .

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The McGraw-Hill TECHNICAL WRITING SERVICE has a staff of more than 150 highly-trained writers, editors, and illustration specialists whose job it is to create technical and general literature for industry. We write, illustrate, design, and print Equipment Manuals, Product Bulletins, Handbooks, Company Histories, Annual Reports, and other specialized material. Save money and time. Let our staff be your staff for Technical and Business publications.

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PRESS PREVIEWS

Three Electronic Firms in Merger

Facilities and personnel of three existing companies have been joined to create a new manufacturer of electrical and electronic components, National-El Ray Co., North Hollywood, Calif. It was formed from El Ray Motor Co., manufacturers of miniature ac and dc motors; Valco Engineering Co., makers of ceramic capacitors; National Electronics Corp., manufacturers of filters, transformers, and electronic heating elements for aircraft and missiles.

New Firm to Manufacture Electrical Contacts

Contacts, Inc., Wethersfield, Conn., has been organized to manufacture electrical contacts. It will offer engineering services in design, development and manufacture, to answer industry needs for specialized solutions to precision electrical-contacting problems. Available later this year will be contacts of tungsten and molybdenum, and composite contacts having facings of rare metals and their alloys. In mid-1958, a complete line of heavy-duty contacts and materials will also be offered.

Electromet Adds to Research Lab

Construction of an addition to the process research building has started at the Metals Research Laboratories of Electro Metallurgical Co., Div. of Union Carbide. The new extension, scheduled for completion in November, will more than double space for research in chemical metallurgy at the company's research and development center, Niagara Falls, N. Y.

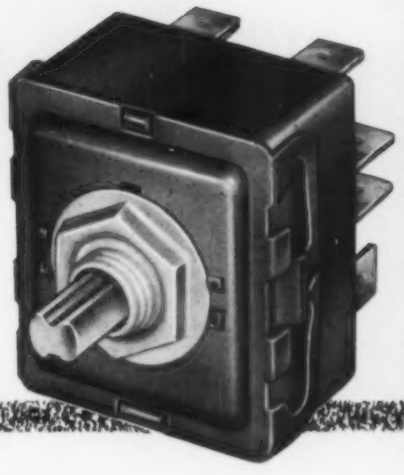
Gear-maker Expands Facilities

An expansion program giving an increase of over 50% in manufacturing space has been announced by the

(Continued on page 210)

Need a Small Switch For a Big Job?

'DIAMOND H' SERIES 390 SWITCHES



For air conditioners, fans, unit heaters, appliances and similar products . . . in motor or resistive circuits . . . Series 390 Rotary Switches have capacities out of all relation to their size.

Though UL approved ratings range up to 25 A. at 120 or 240 V., and ½, ¾ and 1 h. p. at 120 V. and 2 h. p. at 240 V., A. C., with small D. C. ratings also available, *the base of this switch measures only 1½" x 1¼" x ⅞"!* And they are available for from two to 12 positions, with or without stop as required.

HELPS SIMPLIFY YOUR DESIGN

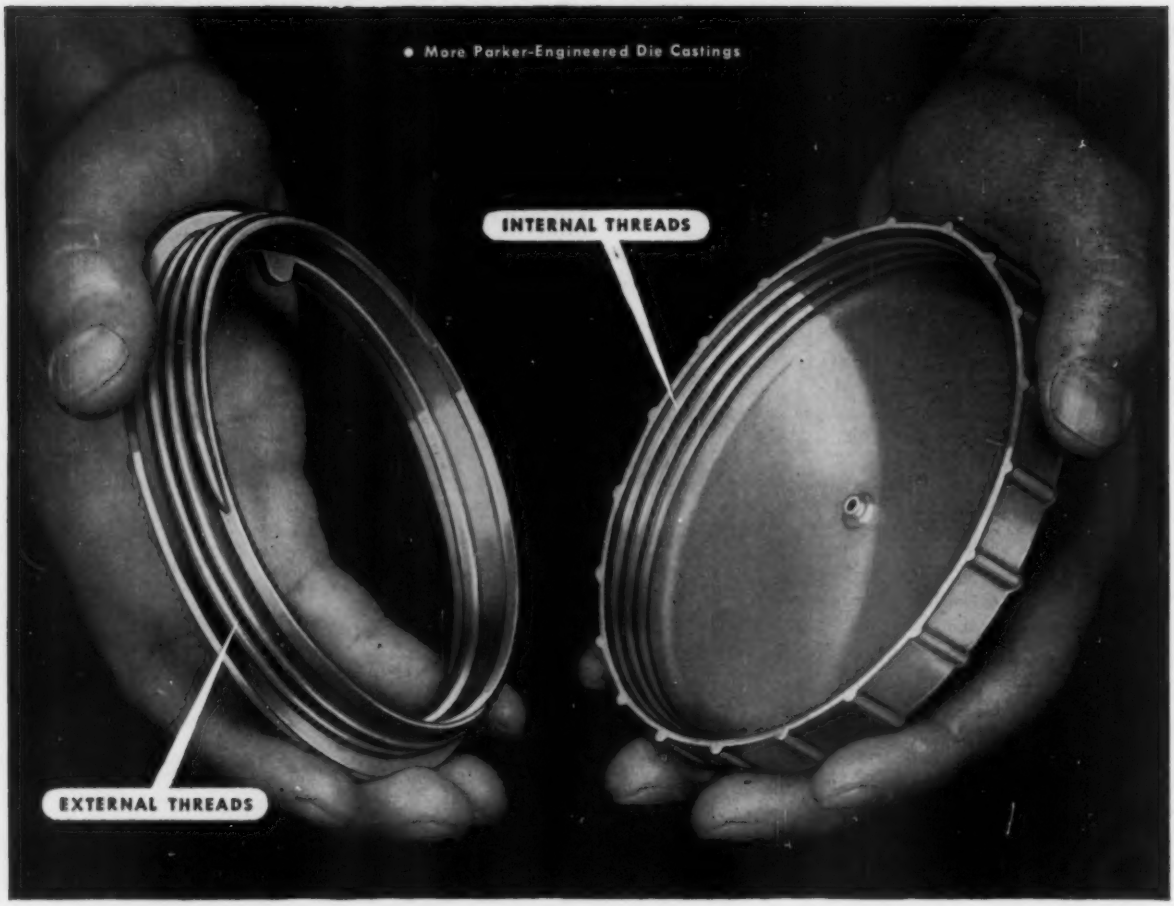
Spindles of Series 390 switches may extend through the base to permit ganging of mechanical and electrical controls. Dummy terminals may be provided to eliminate need for separate blocks. Spade terminals make for fast connections.

Completely interchangeable with the widely used "Diamond H" Series 240 Switches, which are still available, Series 390 includes both single and double pole models for single, two-hole or special mounting arrangements.

Tell us your requirements.

THE HART MANUFACTURING COMPANY

206 Bartholomew Avenue, Hartford, Conn.



From ONE Die: TWO Parts... THREE Savings!

PARKER SALES ENGINEERS

CHICAGO 49, Ill.
Ollie J. Berger Company • 2059 East 72 Street
CINCINNATI 14, Ohio
William H. Braxterman • 2430 Central Parkway
DETROIT 35, Mich.
Hodgson-Geisler Co. • 18917 James Couzens
GIRARD, Penna.
Daniel F. Marsh • 35 Chestnut Street
WILTON, Conn.
Girard L. Palmer • Belden Hill Road
SYRACUSE, N. Y.
J. C. Palmer • 712 State Tower Bldg.
BELLEFONTE, Penna.
Warren G. Olson • 420 East Linn Street
LONG BEACH 11, California
R. W. Fletcher • 2803 Loomis Avenue
PHOENIX, Arizona
Fred B. Larsen • 6108 North 11 Avenue
ST. LOUIS 8, Missouri
Frank May • 4378 Lindell Blvd.
WINTER PARK, Florida
Duane P. Davis • 110 South Orlando Ave.
Box 25

These two mating parts, including the threads, are cast simultaneously in the same die. The result—three savings:

1—One die instead of two *saves die cost*

2—Casting two parts at one time in the same die *saves production time*

3—Precision casting of the perfectly mated threads with no parting line *saves machining cost*

Together, these three savings result in a substantially lower cost per piece. Just another example of the way Parker-engineered die castings save you money.

Parker has been a leader in die casting for over 50 years—an old hand with new ideas. This skill and experience can solve problems — and save money—on *your* component parts. Just call the nearest Parker sales engineer or write the factory direct.

Parker White Metal Company • 2153 McKinley Ave., Erie, Pennsylvania

PARKER

high pressure ALUMINUM and ZINC die castings
POWDERED METAL PARTS

When selecting a timer— design for availability

Specifying one of the many standard units offered saves you and your customers time, money

Several distinct advantages accrue when you design for a standard timer—as against making a special timer for your specific job:

Cost is lower because no engineering or tooling charges are encountered. Service is quicker and easier. Replacement is simplified. Complete descriptive information and operating instructions are in print.

STOCK TIMERS FOR QUICK DELIVERY. But probably the most important single reason for sticking to standards is ready availability. Quantities of the exact type, range and rating can usually be obtained immediately from manufacturer's stock for prototype or test purposes. Production quantities can be supplied with minimum lead time because design has been completed, parts inventories established and assembly techniques perfected.

EXTREME VARIETY AVAILABLE. Leading timer manufacturers offer extremely wide lines of standard interval timers, time delay relays, cycling timers and time totalizers. In addition, a wide selection is offered within these groups. You can, for instance, pick a standard interval, cycling or delay timer to optimize almost any characteristic needed for your design; cost, mounting, accuracy, actuating means, and degree of adjustability. Each of these sub-categories in turn provides various time ranges, control arrangements and voltage-frequency combinations.

MINOR CHANGES EASY. In the event you can not find a stock or catalogued timer to meet your exact needs, discuss your problem with a full-line timer manufacturer. He will frequently be able to modify a similar unit to your specifications with only minor changes, thus saving you the costs of engineering and lengthy testing.

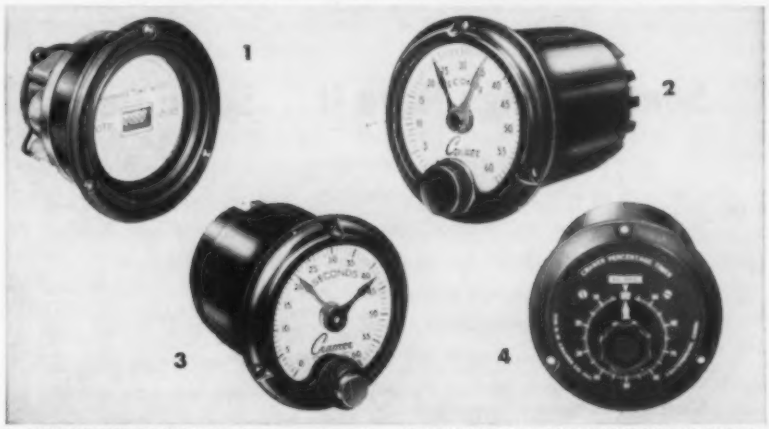
Only rarely will you have to specify a completely new design. And then your best approach is to talk it over with the specialists in the field of time control.

WRITE TIMER SPECS EARLY. Timer requirements should be determined early in the design process, so that an available standard timer, with the right characteristics and proved performance, can be accommodated.

LET US HELP YOU. Cramer engineers are always ready to discuss your time control problems. They can tell you about interval timers, time delay relays, cycling timers and time totalizers in 85 stock variations in the wide Cramer line. And they can handle your special needs, too. Write us or see your local Cramer representative. The Cramer Controls Corporation, Box 7, Centerbrook, Conn.

CRAMER PERMANENT-MAGNET MOTOR—heart of Cramer a-c timers. Available separately. Features fast start, truly synchronous operation, no coasting. *STOCKED* in many speeds, right or left rotation. Various output shafts. Torque: 30 in-oz at 1 rpm. Bulletin PB-110A.

A FEW STOCK TIMERS FROM THE BROAD CRAMER LINE



1. TYPE 631E TIME TOTALIZER. Registers elapsed time on 5-digit drum-type counter. *STOCKED* in total ranges of 9999.9 and 99999 hours at 115V, 60 cps. Also 9999.9 hours at 220V, 60 cps. Other available (including resettable) types count 1/10 seconds, seconds, 1/100 and 1/10 minutes, minutes, 1/10 hours and hours. Bulletin PB-610.

2. NEW TYPE 412 TIME DELAY RELAY. Introduces timed delay between operation of control circuit and load circuit. *STOCKED* in full-scale ranges of 6, 15, 30, 60, 120 seconds; 5, 15, 30, 60 minutes; 5, 12, 24 hours at 115V, 60 cps. Also 15, 60 seconds; 5, 15, 60 minutes at 220V, 60 cps. Bulletin PB-311.

3. NEW TYPE 241 AUTOMATIC RESET INTERVAL TIMER. Provides pushbutton start, automatic and immediate reset for electrically operated equipment. *STOCKED* in full-scale ranges of 6, 15, 30, 60, 120 seconds; 5, 15, 30, 60 minutes; 5, 12, 24 hours at 115V, 60 cps. Also 60 seconds; 5, 15, 60 minutes at 220V, 60 cps. Bulletin PB-241.

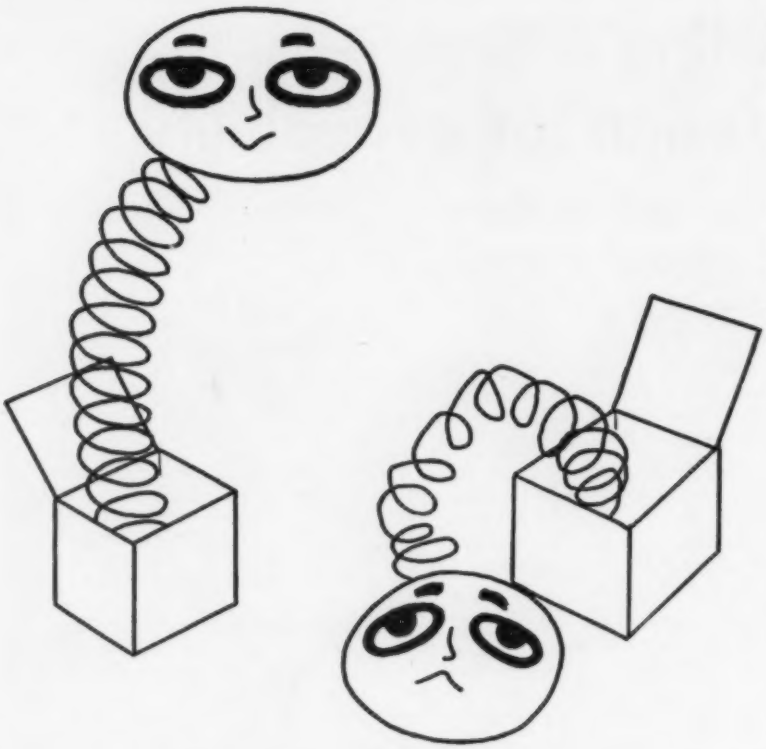
4. TYPE 610 PERCENTAGE TIMER. Makes (or breaks) electrical circuit for adjustable percentage of a fixed time period. Calibrated in steps of 1% from 4 through 96. 100% setting provided. Snap action switch. *STOCKED* in ranges of 15, 30, 60 seconds; 5 minutes at 115V, 60 cps. 15, 30, 60 seconds at 220V, 60 cps. Bulletin PB-510A.

TALK IT OVER WITH CRAMER

CRAMER CONTROLS
CORPORATION

(Formerly R. W. Cramer Co.)

6.16



Some Springs Have It...Some Don't

The difference in spring performance is most often due to the wire or strip used... and there's more to a spring material than just the "bounce". How about other requirements, such as corrosion resistance, high temperature properties, fatigue resistance and low temperature toughness.

When your springs need any of these properties your best bet is one of our alloy spring materials.

Riverside-Alloy Metal Division can supply you with spring wire and strip in stainless steels, nickel alloys, phosphor bronze and beryllium copper.

Learn more about our spring materials. Write to Riverside-Alloy Metal Division, H. K. Porter Company, Inc., Riverside, N. J.

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H. K. PORTER COMPANY, INC.
RIVERSIDE-ALLOY METAL DIVISION

Automotive Gear Div. of Eaton Mfg. Co. Added to the Richmond, Ind. plant will be a 35,000-sq ft building plus 2,800 sq ft of office space. The $2 million facility will mean an expansion of staff to 450. The company makes gears for the farm-equipment, material-handling, automotive, machine-tool and other equipment.

Titanium Pigment Plant Opens in Canada

Canada's first titanium pigment plant, has been officially opened at Varennes, Que. by a National Lead Co. subsidiary, Canadian Titanium Pigments Ltd. The plant will begin full production immediately, output going to the Canadian paint, paper, rubber, and plastics industries. The new operation employs about 300. Since sulfuric acid is an important raw material in titanium pigment processing, a large sulfuric acid plant, using the modern contact process, forms part of the project at Varennes.

New Industrial Research Group

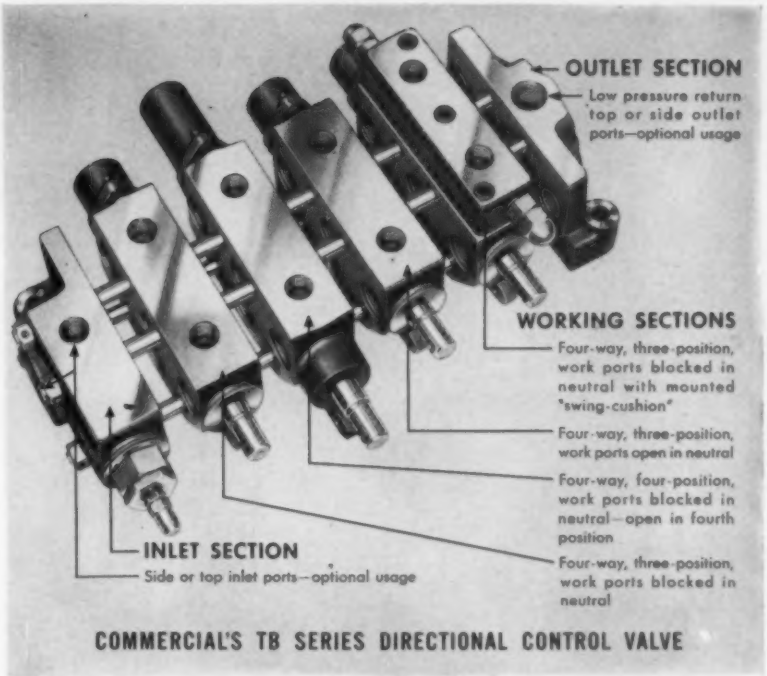
Formation of Hydel, Inc., an independent research and development organization, is announced by 10 former staff members of the Dynamic Analysis and Control Laboratory of MIT. The company will offer engineering service to industry in the field of automatic control. Several members of the group took part at MIT in the development of the first three-axis flight simulator for aircraft and guided missiles, carried on pioneering work in the analysis and design of hydraulic and pneumatic servo-valves, and contributed to the new field of control-systems engineering.

Bendix Expanding Plant Facilities For Missile Work

Pacific Division of Bendix Aviation Corp. is constructing a 12,000 sq ft addition to its manufacturing facilities to provide necessary space for the division's missile programs. The new building area is required primarily for the assembly and testing of hydraulic

(Continued on page 212)

NEW DESIGN IN FLUID POWER CONTROL VALVES


OUTLET SECTION
Low pressure return top or side outlet ports—optional usage
WORKING SECTIONS
Four-way, three-position, work ports blocked in neutral with mounted "swing-cushion"
Four-way, three-position, work ports open in neutral
Four-way, four-position, work ports blocked in neutral—open in fourth position
Four-way, three-position, work ports blocked in neutral
INLET SECTION
Side or top inlet ports—optional usage

COMMERCIAL'S TB SERIES DIRECTIONAL CONTROL VALVE

Pressure Drop Reduced 15%

The higher the back pressure in a control valve the greater the power loss and the less efficient the fluid power system.

Advance design in Commercial's control valves—larger circulatory passageways, more uniform cross sections, smoother wall surfaces, and freedom from abrupt direction changes—lowers internal pressure drop as much as 15%.

Commercial valve performance is increased because flow around large outside surfaces of solid spools is unimpeded—not forced through constricting orifices. And Commercial's valve passageways have equal or greater cross-sectional area than inlet or work ports.

Load Drop Eliminated

Pressurized return flow in many conventional control valves frequently results in erratic operation—sudden movements and one load dropping while another is being positioned.

An individual check, located so as not to cause any passageway constriction, is built into every working section of a Commercial control valve. It blocks all pressurized return flow until it is overcome by pressure build-up from the pump—makes for safe, smooth, precise and accident-free operation.

2000 PSI Operation Perfected

Because of structural design weaknesses in many control valves optimum operation at pressures up to 2000 psi is often not practical or even possible.

With Commercial's control valves operation at pressures up to 2000 psi is recommended. The non-porous grain structure of the high-strength, semi-steel castings used in Commercial's valve sections prevents seepage of pressurized oil. And because of their greater strength the section castings do not distort when stressed under pressure.

The use of O-rings—instead of gaskets—for all sealing between sections and at the ends of spools assures leakproof operation. Elimination of gaskets between sections also precludes overstress and distortion of section castings to prevent possible leakage.

Overload Protection Built In

A combination overload relief-pressure valve—incorporated right in the housing of Commercial's control valves—provides positive safety protection for the fluid power system, plus overload protection for the structural members and tools of the machine in operation. Its complete cartridge construction permits easy removal from the inlet section of the valve bank—for quick inspection or replacement.

Rated on Performance

For the purpose of greater accuracy all Commercial control valves are rated on the basis of performance—not mere size of inlet and outlet ports alone. With Commercial's "performance-rated" control valves proper valve selection for any fluid power system is based on total pressure drop values when assembled in various combinations of actual operating actions.

Commercial's control valves involve parallel circuit operation—provide pressure to two or more operations simultaneously when so desired. Working sections having three-way, three-position; four-way, three-position; and four-way, four-position actions, are available and can be assembled independently in any combination or sequence.

Engineering Help Available

The technical help Commercial sales engineers can offer on the application of Commercial fluid power valves, pumps, motors and cylinders, can easily contribute the kind of fluid power cost savings and improved performance you are looking for and need.

ENGINEERING DATA FREE

For more information write to Dept. G-42, Commercial Shearing and Stamping Company, Youngstown 1, Ohio. For your copies of Commercial's fluid power engineering bulletins just check the items below in which you are interested and attach to your letterhead.

- ☐ "Performance Rated" Valves, Catalog H-12
- ☐ Oil-Hydraulic Pumps and Motors, Catalog H-4
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400 CPS . . . *miniature and heavy-duty models for airborne instrumentation.*

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HEADQUARTERS FOR TIMING

A SUBSIDIARY OF GENERAL TIME CORPORATION

HAYDON Manufacturing Company, Inc.
3134 ELM STREET, TORRINGTON, CONN.

components being produced under contract by the division for the Atlas, Titan, Nike, Terrier, Talos, Sparrow and other missiles slated for future production.

The building is designed specifically to meet the standards required for temperature and contamination control in the assembly and testing of missile hydraulics. Air-lock double doors will be installed at all entrances. There will be no windows. Equipment includes test facilities for high-temperature oil.

Development Center For Narmco

A $1 million industrial research and development center for Narmco, Inc., San Diego, Calif., is now under construction. The center will work with advanced design products and materials for aircraft and commercial industries, and will be in operation next year. The company manufactures structural adhesives, reinforced plastics and sandwich-type structures.

Another Small-motor Plant for Westinghouse

The newest of four such plants operated by Westinghouse Electric Corporation's small-motor division, a one-story, 66,000-sq ft producer has been opened at Upper Sandusky, Ohio. It will manufacture two motor types, shaded-pole and permanent-split capacitor, in about 30 styles and sizes.

Both types feature self-aligning steel-backed, babbitt-lined sleeve bearings and an original oil supply for at least five years' normal operation.

Count on *Continental* to

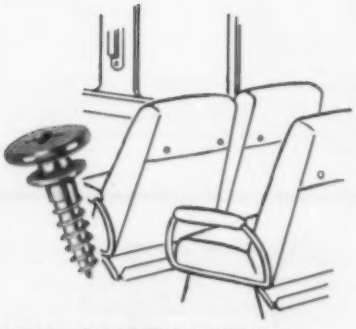
meet special fastening problems

with specialized cost-saving experience

Continental Assembly Engineers' Specialized approach to fastener trouble-shooting assignments gets you the right answer promptly, with the biggest cost savings — for two reasons.

First, since Continental can supply more types of standard fasteners, from stock, their recommendations are unbiased. They can tell you if some "standard" you've overlooked will meet your needs.

Second, if a "special" is the best answer, you can rely on Continental's unlimited experience to design and produce a fastener that will meet all specifications at the lowest possible cost.

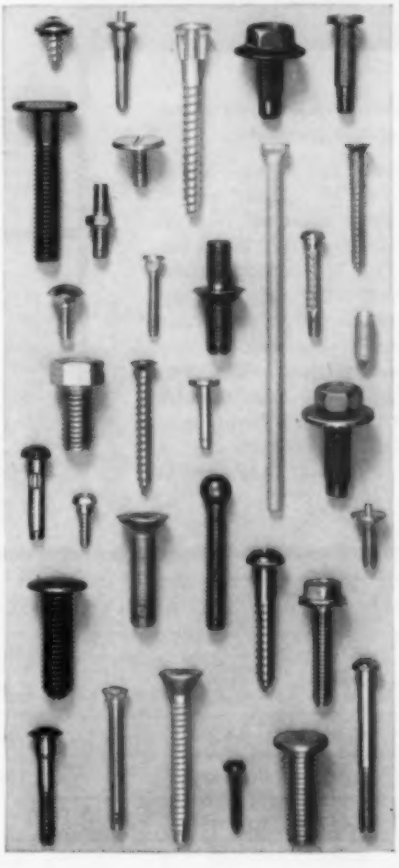


SPECIAL HOLTITE® PHILLIPS
button-head screw replaces two-piece fastening . . .

A bus builder asked Continental Assembly Specialists how to simplify installation of towel-holding buttons on back of bus seats. Separate wood screw and metal button being used caused slow work, with many pieces dropped and wasted.

One-piece button head special screw designed by Continental reduced parts cost 10%. Easy installation of simplified fastener provides much bigger saving in assembly costs.

COST LESS SPEED ASSEMBLY



HOLTITE® NYLOK®
self-locking screws solve problem of screws loosening in chain saw

When consulted by a chain saw maker on the problem of screws vibrating out, Continental Assembly Specialists had the answer in HOLTITE® NYLOK. Two of the several types of machine screws furnished, all fitted with the resilient nylon plug, are illustrated. These NYLOK screws do not loosen in spite of extreme vibration, keep the saws "on-the-job". Previous customer complaints of high maintenance costs were eliminated.

END COMPLAINTS OF HIGH MAINTENANCE COSTS

"Special" attention like this will pay off for you . . .

It costs you nothing to talk to a Continental Assembly Specialist. And, as soon as he digs into your problem, you'll see what we mean by "specialized experience". For prompt service, write or phone: Continental Screw Co., 452 Mt. Pleasant St., New Bedford, Mass.

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HOLTITE FASTENERS

HOLTITE PHILLIPS AND SLOTTED HEAD
WOOD • MACHINE • TAPPING • THREAD CUTTING • SEMS • NYLOK
HY-PRO PHILLIPS INSERT BITS AND HOLDERS

glass-base laminates?

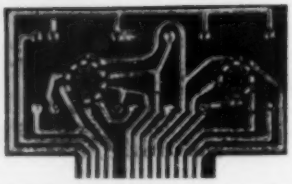
C-D-F DILECTO®
is the answer!

Teflon*, silicone, epoxy, melamine, and phenolic glass-fabric laminates. Polyester glass-mat laminates.

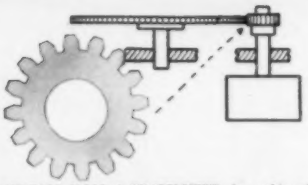
You can improve design, speed production, and save money by specifying one of the many C-D-F Dilecto grades. Whatever your application for these laminates — with fine- or medium-weave glass-cloth base — you'll find a better answer to your problem at C-D-F. (Melamine can also be made with glass-mat base.) And C-D-F offers modern machining and fabrication facilities to deliver production quantities of finished Dilecto parts to your specifications.

See our catalog in Sweet's Product Design File, where the phone number of your nearby C-D-F sales engineer is listed. For free trial samples of glass-base Dilecto, or of any other C-D-F plastics, mica, or fibre product, send us your print or your problem! Write for your free copy of C-D-F Technical Bulletin 64.

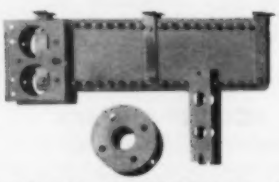
*DUPONT TRADEMARK FOR TETRAFLUOROETHYLENE RESIN



SPEED AUTOMATIC PRODUCTION of printed circuits with warp-resistant C-D-F metal-clad Teflon* and epoxy laminates. Other advantages: high bond strength of copper to laminate, superior blister-resistance in solder immersion.



HIGH-VOLTAGE (1800v.) RF ISOLATION is achieved by miniature C-D-F Dilecto gears in an aircraft receiver-transmitter switch. They also had to exhibit dimensional stability through a wide temperature range, resistance to fungus growth and thermal shock.



PRECISE MACHINING AND FABRICATION are standard benefits of Dilecto laminated plastics. These silicone glass-base parts (coil mountings, aircraft terminal board) were sawed, drilled, punched, and milled in production quantities by C-D-F and customer.

PROPERTIES OF SOME TYPICAL C-D-F DILECTO GLASS-BASE GRADES

Grade	Equivalent NEMA or ASTM grade	Flexural Strength Lengthwise (PSI)	Dissipation Factor at 10⁶ Cond. A	Dielectric Strength Parallel Step x step	Insulation Resistance Cond. C96/35/90	Arc Resistance (seconds)	Maximum Operating Temp. (°C.)
GB-112T (Teflon*)	None	14,000	0.0015	65	100,000	180 +	250
GB-12S (Silicone)	G-7	28,000	0.002	60	100,000	180+	200
GB-28E (Epoxy)	G-10	70,000	0.019	65	75,000	130	150
GB-28EFR (Flame-Retardant Epoxy)	G-10	68,000	0.010	65	100,000	180	150
GB-28M (Melamine)	G-5	50,000	0.014	50	100	185	135
GB-261D (Phenolic)	G-1 and G-2	22,000	0.020	55	10,000	5	150
GM-PE (Polyester)	GPO-1	35,000	0.020	70	200	130	150

These are typical grades for typical applications. To meet special requirements, C-D-F makes many other Dilecto grades, one of which may serve your purpose better than any of these listed here. Consult the C-D-F Technical Department for expert assistance with your design problem involving laminated plastics products.

CDF

CONTINENTAL-DIAMOND FIBRE

A SUBSIDIARY OF THE Bakelite COMPANY • NEWARK 40, DELAWARE

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Of Product Engineering published during past year monthly with add'l issue in mid-October, at Albany, N. Y., for October 1, 1957.

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McGRAW-HILL PUBLISHING COMPANY, INC.
By JOHN J. COOKE, Secretary.

Sworn to and subscribed before me this 3rd day of September, 1957.

[SEAL] JANET A. HARTWICK.
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A challenging opportunity to create

A challenging future with a small growth company is offered the engineer who is interested in a career opportunity utilizing his training and technical know-how.

Responsible engineering positions exist in the machine design and development of xerographic equipment. Xerography, a process for forming and using electro static images, is widely used in the copying and duplicating field. It is being developed for fascinating applications in automatic data processing, photography, office equipment, engineering drawing systems and interesting military applications.

Opportunities are available at all levels. There are openings also in products improvement and engineering standards work. Assignments are largely of the electro-mechanical type with a variety of optical, lighting, and electrostatic problems.

Previous experience in the design of office equipment or photographic equipment (military or commercial) would be helpful.

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MORE EFFICIENT DESIGN, IMPORTANT SAVINGS, SIMPLIFIED ASSEMBLY, BETTER APPEARANCE

These are some of the many benefits reported by Design Engineers who have adopted TRU-LAY PUSH-PULLS for remote control operations on literally hundreds of products

Here are typical comments recently received from equipment manufacturers whose machines or implements are equipped with these accurate and dependable remote controls:

Saves Time, Labor and Material
"The use of your flexible Push-Pulls saves us a great deal of time, labor and material. The old linkages frequently required much planning in both engineering and shop which is not required now. On some of our equipment we use Push-Pulls from 10 to 30 feet in length. They operate clutch controls on the Main Power Unit, Feed Conveyors and Delivery Conveyors."

Greater Flexibility of Design
"The principal advantage of Tru-Lay Push-Pulls in our application is that they permit flexibility in locating the control valve in relation to the operator's position."

Cost Less to Install
"Tru-Lay Push-Pulls are easier and less expensive to install than linkages for remote control of power take-off, brake and clutch. Better appearance, too."

Simple and Neat
"For several models of farm tractors, we selected your controls for their simplicity and neatness of application as governor controls."

Solution to Tough Problem
"Can be installed where straight rods are impossible . . . for Remote Control of transmissions, brakes and clutches."

Eliminates Maintenance
"Simple operation and elimination of maintenance problem are the major advantages in using your Push-Pulls."

Reduces Number of Parts
"Your Push-Pulls have eliminated links, radius rods and other lost-motion devices for remote control of hydraulic valves."

Provide ACCURATE Control
"Tru-Lay Push-Pull control cables provide minimum back-lash, even in installations up to 30 feet in length, because the cable is designed to close tolerances with minimum drag and lost motion."

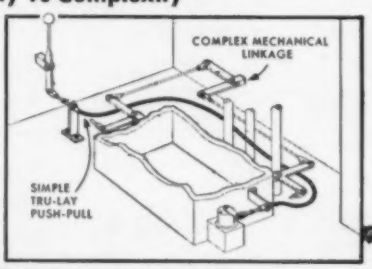
• • •

TRU-LAY PUSH-PULLS are "Solid as a rod but *Flexible* as a wire rope." This flexibility makes it possible to snake around obstructions . . . permits the ideal arrangement of all elements of remote controls.

***Advantages** of Tru-Lay Push-Pull flexibility and simplicity are pictured below—*

Simplicity vs Complexity

Compare the TRU-LAY PUSH-PULL cable in illustration with the mechanical linkage. PUSH-PULLS are simple, have but one moving part, are noiseless and give lifetime service accuracy. Linkages are complex, made of many parts; they wear at many points. Their use brings increased backlash, lost accuracy and vibration rattles.



Construction Equipment and **Farm Implements** provide good examples of the wide-spread use of these accurate, simple and dependable Push-Pulls. On Power Shovels, Winches, Graders, Road Oilers, Dump Trucks, Snow Plows, Engine-driven Pumps, Crushers, Tractors, Combines, Corn Pickers, Corn Row Sprayers, Corn Detasslers, Orchard Sprayers, Power-driven Tree Trimmers, Tobacco Picking Machines and others . . .

TRU-LAY PUSH-PULLS are operating unfailingly for the remote control of Hydraulic and Air Valves, Brakes, Clutches, Transmissions, Throttles, Chokes, Governors, Power Take-Offs, Spray Nozzles, Vent Directional Fins and on many other applications.

ACCO *Our DATA FILE will answer all further questions*

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TRADE MARK

There is No Worry about Failures or Maintenance Costs with TRU-LAY Push-Pull Remote Controls

Long Life is a matter of record. We have never heard of a Tru-Lay Flexible Push-Pull Control wearing out in normal service. Failures, that sometimes harass users of more complex controls, are eliminated by the use of these simple, positive-action controls.

Dependable Operation of these controls is a certainty, even under the most adverse conditions . . . HOT as jet engines (note: Tru-Lay Push-Pulls are actually performing on hot jet applications) . . . COLD to 70° F below zero . . . SOAKIN' WET . . . ABRASIVE . . . or just plain TOUGH.

Freedom from Trouble is assured because of such features as . . . full protection of the inner, working member by the tough flexible conduit . . . lubrication of the inner, working member *for life* during assembly . . . seals that keep moisture, dust and other foreign matter out of the unit . . . cold swaging of fittings that makes them integral parts of the control unit.

Accuracy is inherent in the basic design of Tru-Lay Push-Pulls. They are precision products, not gadgets.

Capacity ranges from light jobs up to jobs of 1,000 lbs. input. These Push-Pulls will handle jobs 150 feet or more from the control point.

"Solid as a rod, Flexible as a wire rope" aptly describes Tru-Lay Push-Pull Controls. This flexibility provides positive, remote action whether anchorages are fixed or movable . . . it damps out noise and vibration . . . it greatly simplifies installation of controls by reducing the number of working parts and by making it possible to snake around obstructions.

Adaptability to all sorts of mechanical situations explains, in large measure, the wide-spread application of Tru-Lay Push-Pulls. Standard anchorages, fittings and heads have been designed that meet requirements on approximately 80% of the installations. Simple modifications of these standards, or minor changes in your own design, cover almost every special situation. Our engineers have the know-how on such matters, and will work with you.

For Further Information—The DATA FILE pictured at the left contains six booklets and bulletins that will answer any further questions you may have about this versatile and dependable tool. It is quite likely that this material will point the way to a simplified solution of your remote control design problems. Write for a copy.

More Details?

about

- **products advertised**
- **new components and materials**
- **new catalogs and bulletins**

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Now, one of these handy prepaid postcards will bring you more information about any product advertised or mentioned editorially in this issue of *Product Engineering*.

Here's How to Use the Card

For your copy of any new catalog or bulletin, circle key numbers in the space indicated. Bulletins are described on pages 158-172.

To get more data about new Components, Materials and Parts fully described on pages 127-156, just circle the appropriate key number.

To get more information about advertised products, circle the page number of the advertisement in which you are interested. If more than one advertisement is located on a single page, letters preceding number identify each advertisement. Key: T—Top; B—Bottom; R—Right; L—Left; TL—Top left; BL—Bottom left; TR—Top right; BR—Bottom right.

For specialized data . . . prices, sizes available, nearest source of supply, etc. . . . do not circle key number but indicate your needs in the space allotted at the bottom of the card. Use this space, too, if information about a specific product among several mentioned in an advertisement is desired.

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Description of these new engineering materials appear on pages 127-156. Circle key number for more data

1—Differential Pressure Transducer
2—Digital Torque Measuring System
3—Remote Counter
4—Vacuum Eliminates Oil Leaks
5—Miniature 3 and 4-digit Counter
6—Double-ring Lock Washer
7—Heavy-duty Rotary Pumps
8—Thin Metal Parts Without Dies
9—5-way Hydraulic Control Valve
10—Limit Switch With 1-way Action
11—Hydraulic Torque Booster
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13—High-strength Silicone Rubber
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16—Rotary Switch
17—Fast-curing Molding Material
18—High-temperature Transducer
19—Servo-mounted Brake
20—Power Transmission Belt
21—Self-bonding Metal Nameplate
22—Line of Fhp Motors
23—Magnetic-friction Clutches
24—Self-locking Bolt
25—Self-locking Screws
26—High-speed Transmission Belt
27—Anti-backlash Gear Assemblies
28—Mylar-insulated Metal Screw
29—Phase-sensitive Ac Voltmeter
30—16-amp Paralleling Reactors
31—Magnetic Mercury Switch
32—Cellular Rubber Extrusions
33—Taper-bored Flexible Couplings
34—Permanently Sealed Caster
35—Heavy-duty Toggle Switch
36—Ten-contact Relay
37—Rotating Cam Limit Switch
38—Direct-reading 10-turn Dial
39—Shaft-retention Fasteners
40—Hand Vibrometer
41—High-speed Telephone Relay

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54—Electronic Breadboard Equipment, 4 pp, Sterling Precision Corp.
55—Switches, 2 pp, Micro Switch Div., Minneapolis-Honeywell
56—Clutches, 8 pp, Curtiss-Wright Corp.
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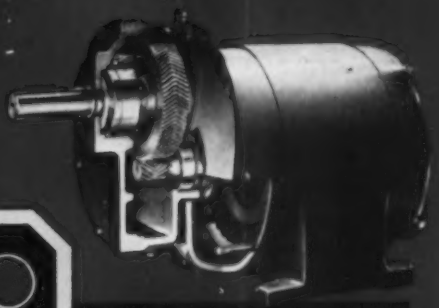
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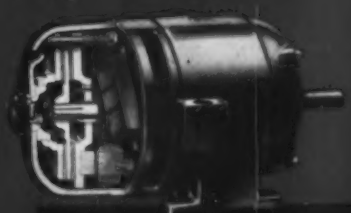
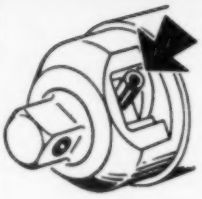
Right-Angle Shaft Gearmotors


Unibrake Motors

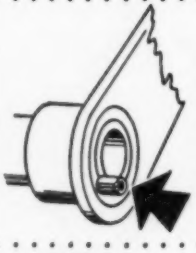
Speedrangers

Standard Motors—⅛ to 400 H.P.

Rollpin® replaces 12 different fasteners

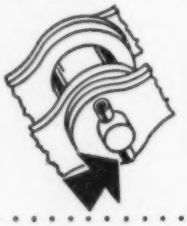


REPLACING A GROOVED PIN . . . in this application, Rollpin serves as a stop pin in a ratchet wrench adaptor. With its light weight and high shear strength, Rollpin functions perfectly . . . cuts assembly costs.



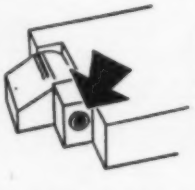
REPLACING A KEY . . . Rollpin demonstrates its ability to do away with precision tolerances, in this heating system damper arm. Faster, cheaper and more satisfactory than previous assemblies.

REPLACING A RIVET SHAFT . . . Rollpin serves as an axle for the sparkwheel of a cigarette lighter. No riveting or threading necessary . . . faster assembly. Note flush, clean fit.

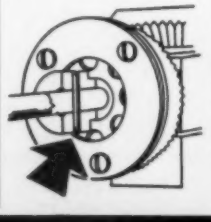


REPLACING A COTTER PIN . . . Rollpin assembly time is shorter, service life ten times longer. Vibration-proof flush fit. Easily removable.

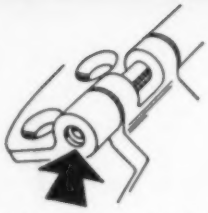
REPLACING A SET SCREW . . . to fasten automobile brake handle a short length Rollpin is self-retained in the hand grip but can easily be driven into over-drilled hole in shaft for simple handle removal.



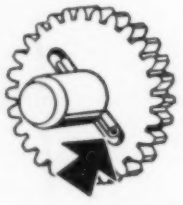
REPLACING A CLEVIS PIN . . . here Rollpin holds firmly in clevis, permits free action of moving member. Rollpin application shown is the plate of a home workshop tool.



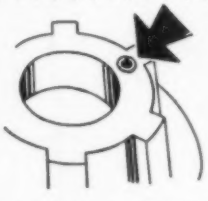
REPLACING TAPER PINS . . . in the assembly of precision differentials eliminated cost of taper pin reamers and the entire reaming operation. Rollpin costs less than a taper pin and installation is cheaper. They remove easily.



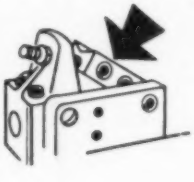
REPLACING A HEADED PIN . . . in this hinge pin application, Rollpin is simply and inexpensively driven in place, greatly reducing assembly costs. Constant spring tension holds Rollpin firmly in place . . . eliminates loosening of hinge due to wear.



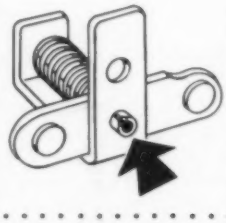
REPLACING A HUB ON A GEAR . . . Rollpin, self-retained in shaft, is simply snapped into molded slot to position sintered gear. This application, by an office equipment manufacturer, effects major savings in assembly. Rollpin's high shear strength is particularly valuable here.



REPLACING A DOWEL PIN . . . Rollpin is used here to prevent rotation of a thrust bearing. No reaming, no special locking. Easily removed. Lowest possible dowel pin cost.



REPLACING A BOLT AND NUT . . . Rollpins act as fasteners and pivots for the linkages in this electric welder. Rollpins may be used with a free fit in outer or inner members depending upon product design requirements.



REPLACING A RIVET . . . Rollpin serves as guide shaft for spring-loaded electrical interlock contacts. This electrical equipment manufacturer reports that rivet failure previously occurred at the clinched end under normal operating impact and vibration.

WHERE CAN YOU USE THIS SIMPLE FASTENER?

Rollpin is the slotted tubular steel pin with chamfered ends that is cutting production and maintenance costs in every class of industry.

Drives easily into standard holes, compressing as driven. Spring action locks it in place—regardless of impact loading, stress reversals or severe vibration. Rollpin is readily removable and can be re-used in the same hole. Made in carbon steel, stainless steel and beryllium copper. Write for samples and information, ELASTIC STOP NUT CORPORATION OF AMERICA,
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